Investment under Stormy Skies:

The Case of Russian Firms during 2004-2016*

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Abstract

In this study, we examine the impact of sanctions on investment in Russia over the period 2004-2016. Our objective is two-fold. First, we examine the investment response to the sanctions imposed on entities and firms in 2014 using a rich panel of Russian non-financial firms. We exploit firm-level and sectoral variation in our micro-level data set that covers both large firms and SMEs. In this analysis, we employ a reduced-form investment equation that allows for the effect of sanctions together with other determinants of investment behavior and control for the heterogeneous effects of the ruble devaluation and oil price decline that occurred concurrently with the sanctions regime. We verify our identification strategy by examining response of investment of Russian non-financial firms during the 2008 invasion of Georgia as well as that of Kazakh firms to the 2014 sanctions. We also model the impact of sanctions in terms of a structural model of a firm that operates in foreign and domestic markets and that faces regime shifts in a model with partially irreversible investment decisions. Using this framework, we conduct a variety of experiments involving the tightening of sanctions on imported intermediate inputs or imposing an oil price cap.

Keywords: Sanctions, regime changes, wait-and-see motive, Russian Federation, oil price shock, ruble devaluation, firm-level data
JEL Codes: C33, D22, G31

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1 Introduction

Like many emerging market economies, the Russian economy has been subject to significant sources of uncertainty and volatility since its transition from a planned economy in the 1990's. Unlike other emerging economies, however, the recent Russian experience has also been characterized by the imposition of different rounds of sanctions following the annexation of Crimea by Russia in February 2014 and the hostilities in eastern Ukraine paved the way for sanctions on Russian individuals and entities in March 2014 together with a more comprehensive set of sanctions following Russia's invasion of Ukraine in February 2022. Together with the imposition of sanctions, the Russian economy experienced a variety of other macroeconomic disturbances during 2014-2016. As Gurvich and Prilepskiy (2015) notes, there were significant declines in capital inflows, decreasing foreign direct and portfolio investment, fewer borrowing opportunities for companies not affected by sanctions, as well as significant ruble devaluation and interest rate hikes. In early 2014, the price of Urals crude oil fell from highs of over \$100 per barrel to the low \$30's by the beginning of 2016; see Stocker et al. (2018), who note this is one of three largest oil price declines since WWII.[1]

There are now a number of studies that have examined the impact of sanctions on the Russian economy. These studies typically take the sanctions implemented against Russia as a policy shock is exogenous to any individual firm to justify a quasi-experimental approach in their analysis. Belin and Hanousek (2020) examine the efficacy of the reciprocal sanctions imposed by Russia and the EU on bilateral trade flows between Russia, on the one hand, and the EU and US, on the other. Ahn and Ludema (2020) find that targeted firms in Russia suffered in terms of lost operating revenue, asset value and employment and further, that firms that rely on imported inputs were affected the most negatively. By contrast, Crozet and Hinz (2020) attribute the decline of exports of non-embargo products by sanctioning countries to increases in country risk. The findings in Mamonov et al. (2021) suggest that while overall lending may not have been affected by the sanctions in 2014, corporate loans declined significantly, suggesting another channel for the transmission of the sanctions shock. Hence, while macroeconomic impact of sanctions are typically found to be small precisely because such sanctions were intended to affect the long-term health of Russian companies through their ac-

[1] They cite supply factors such as the efficiency gains in US shale oil production and the declining role of the OPEC cartel as well as weakening global demand, especially during 2015-2016, as reasons being behind the collapse of oil prices during this period.

cess to credit or technology, nevertheless these findings suggest several channels for the propagation of the impact of sanctions, which we subsequently discuss.

Our paper has several objectives. First, we seek to understand empirically the impact of sanctions on investment behavior by non-financial firms in Russia over the period 2004-2016 using a rich panel data set on Russian non-financial firms obtained from the Ruslana historical product compiled by Bureau van Dijk. The Russian data set obtained from this product provides comprehensive coverage of firms operating in Russian non-financial sector, accounting for 70% of the gross value added reported by the Russian statistical agency Rosstat in 2014. This data set covers not only large publicly-listed firms, as in most of the literature studying investment and employment, but also privately-held firms, ranging from micro enterprises and SMEs to large firms and mimics the firm-size distribution in the SME sector of the Russian economy. This data set, in our mind, is uniquely suited to studying the investment behaviour of non-financial firms under the sometimes sunny but often times stormy skies that characterize the Russian economy over the period 2004-2016.

In our empirical analysis, we use a reduced-form investment equation that has been studied extensively in the literature and that incorporates the impact of sanctions jointly with firm characteristics and confounding macroeconomic factors. Our aim is to identify the impact of sanctions on firm-level investment after controlling for a variety of geopolitical and macroeconomic phenomena that may also affect the firm's behavior. A key aspect of our analysis is that we seek to control for the heterogeneous impact of confounding events such as ruble devaluation, sanctioned trade, and decline in the price of oil on firm-level investment during the sanctions regime. For this purpose, we exploit firm-level and sectoral variation in sector-level data jointly with our firm-level data set. Hence, we may view this exercise as better identifying the impact of sanctions on the investment behaviour of Russian non-financial firms by isolating it from general equilibrium-like effects.

To identify the confounding effects of foreign exchange exposure working, for example, through bank lending and firm balance sheet channels, following Kalemli-Ozcan et al. (2021), we create an index to determine firms that have high levels of foreign exchange denominated debt. We also examine the indirect effect of sanctions on firm-level investment behavior in Russia. For this purpose, we create a novel proxy which aims to exploit sectoral variation in terms of trade linkages with which Russian firms connect to those countries that have imposed trade sanctions on the non-energy producing sector in Russia. The approach of seeking to identify the sector-specific effects of risk and uncertainty is also followed by Caldara and Iacoviello (2022).

One of the key events during the 2014-2015 is the reduction in the price of oil. This may have the effect of reducing the revenues for the Russian economy, hence, acting like a negative "demand shock" (Goryunov et al. (2015)). A decline in the price of oil may also have the aspect of a "supply shock" by reducing the price of inputs for non-energy-producing firms and hence, their costs of production. Wachtmeister et al. (2023) also note that an oil price cap may have conflicting effects in terms of Russian oil producer losses and hence, government income losses which, in turn, may be offset by Russian domestic consumer benefits. In our empirical analysis, we account for potential heterogeneity on the supply side for the impact of changes in the price of oil by incorporating an index of cost-side oil dependence in production measured as the share of oil inputs in output in our estimation.

Our identification approach is to exploit the timing of the sanctions shock as it interacts with the predetermined values of foreign exchange debt exposure, the sanctioned trade linkage, and oil cost dependence, which are not allowed to change with the shock. This identification strategy necessitates an assumption that any remaining variation in ex-post firm-specific conditions during the sanctions regime does not systematically vary based on ex-ante foreign exchange exposure risk, the sanctioned trade channel, and oil-cost dependence in production.

Our empirical findings indicate that the sanctions regime has a negative impact on firm-level investment after controlling for the effects of factors such as economic policy uncertainty that may affect investment negatively. We find that during the sanctions regime, Russian non-financial firms reduce their gross investment rate by an average of 29% relative to the non-sanctions regime. This negative effect is amplified for firms with sanctioned trade linkages and foreign exchange exposure. In terms of the heterogeneous effects on investment behavior, we find a significant negative effect of the sanctions shock on firm-level investment that works through the sanctioned trade channel after controlling for other confounding effects. In fact, firms operating in sectors with stronger trade linkages with sanctioning countries reduce their investment rate by around 1% more than firms operating in sectors with weaker trade linkages. We further find that firms with high FX debt exposure suffer a decline in their investment rate between 0.9-1.1% relative to firms with lower FX debt exposure. Our findings remain robust when we account for potential confounding macroeconomic factors, ensuring that the observed reduction in investment is primarily driven by the imposition of sanctions rather than other uncertainty-inducing events.

We also consider two placebo experiments to bolster our identification strategy with respect to the effect of sanctions on investment behavior by Russian non-financial firms. Our first experiment falsely assumes that the invasion of Georgia by Russia in 2008 resulted in sanctions. We also consider a sample of Kazakh firms and find that the dummy variable for the post-2014 period as well as the Economic Policy Uncertainty index are positively but insignificantly estimated for these firms. We thus show that our analysis is specific to the effect of sanctions and does not capture invasion-related effects or increases in geopolitical risk that might affect firms in neighboring countries such as Kazakhstan.

Second, we examine the implications of a model with regime shifts and investment irreversibility and expandability to better illustrate the channels through which FX exposure, the sanctioned trade linkage, and oil-cost dependence affect investment behavior. According to this framework, the economic and political sanctions imposed on various individuals and entities in the Russian Federation in 2014 may be viewed in terms of political risk and regime shifts, where the sanctions regime corresponds to a regime with less favorable fundamentals than the regime with no sanctions.[2] In our numerical analysis, we create composite variables showing the impact of demand, productivity and exchange rate conditions for firms operating in the domestic versus foreign sectors. These variables capture the effects not only of trade restrictions imposed on Russian non-financial firms during the sanctions regime but also the competitiveness channel of a change in exchange rates and the oil price decline. We model the joint behavior of these variables using a Markov switching model to capture potential regime shifts in their behavior due to the sanctions regime. Using our theoretical framework, we conduct a variety of experiments such as increasing the fractions of sanctioned imported intermediate inputs and imposing an oil price cap. We believe that these experiments are informative of the effects of sanctions that have been imposed on Russian non-financial firms first in 2014-2016 and later in 2022.

[2]As Drobyshevsky et al. (2018) note, the sanctions regime may lead to a more adverse environment for the Russian economy by affecting the supply of modern technological equipment (such as oil-and-gas, telecommunications and other equipment) and thus slowing down the diffusion of technology, thereby reducing it long-term technological development trend.

The remainder of this paper is organized as follows. Section 2 provides a literature review. Section 3 describes the data. Sections 4 presents the empirical framework while Section 5 presents the structural model and its simulations. Section 6 concludes. Appendix Section A presents further results on the solution and simulation of the theoretical model. Appendix Section B presents further details on data construction and cleaning procedures.

2 Sanctions: A Review of the Russian Experience

In this section, we initially provide a review of the literature that has dealt with the impact of the imposition of sanctions on firms, banks and the aggregate level. We then describe the sanctions imposed since 2014 on the Russian economy as well as re-creating the macroeconomic environment during 2014, which is the focus of our study.

2.1 Literature Review

The form and efficacy of sanctions and the cost they impose on their intended targets have been the topic of much discussion. The economic impact of sanctions has typically been judged using aggregate measures based on subjective assessments of the welfare cost of the trade and financial flows involved; (Hufbauer et al., 2009) who also argue for comprehensive sanctions compared to targeted sanctions. Yet such measures have been criticized on the grounds that they cannot differentiate the effects of simultaneously occurring macroeconomic phenomena in the targeted country and they may not be informative about the effect of the smart sanctions. As Kaempfer and Lowenberg (2007) and other have argued, the channels through which sanctions impact economic activity are specific to the nature of sanctions and the political and economic environment prior to and during the sanctions regime at the sanctioned country. They note that while trade and financial sanctions may have damaging effects on the targeted economy, these may not translate into policy changes by the target regime. Instead they advocate the use of "smart sanctions" that reduce the support of pro-regime elements at the same time as emboldening opposition groups.

Felbermayr et al. (2020) create a global sanctions database that covers all bilateral, multilateral, and plurilateral sanctions in the world during the 1950–2016 period and record their type, political objective, and extent of success encompassing the period.[3] Using a structural gravity model, they find that bilateral sanctions and export sanctions are more effective in reducing trade than are sanctions on imports. Further, the find that complete trade sanctions are more effective than partial trade sanctions. Jäkel et al. (2022) study how different types of sanctions affect the export behaviour of firms to the targeted countries. They combine Danish register data, including information on firm-destination specific exports, with information on sanctions imposed by Denmark from the Global Sanctions Database. They find that on average, sanctions lead to a significant reduction in firms' destination-specific exports and a significant the countries subject to sanction. Using a structural gravity model, Larch et al. (2021) find that agricultural trade with Russia falls as a result of sanctions, particularly for EU-Russian trade which declines by about 51%.

Hausmann et al. (2022) propose a theoretically-grounded criterion for targeting export bans at the 6-digit HS level to study the effectiveness of export restrictions to the sanctioned countries. Using their criterion, they quantitatively evaluate the impact of export bans imposed on Russia following its invasion of Ukraine in February 2022. Their results demonstrate that: (i) export bans are highly effective, with the costs to Russia typically being around 100 times larger than the costs to the sanctioning parties. (ii) Improved coordination of the sanctions and targeting sanctions based on their criteria can increase the costs to Russia by approximately 60% with minimal additional costs to the sanctioning parties. (iii) There is potential to further increase the costs to Russia by expanding the set of sanctioned products.

The impact of sanctions imposed by the EU and the US has also been studied using bilateral trade and firm- and product-level data. Belin and Hanousek (2020) examine the efficacy of the reciprocal sanctions imposed by Russia and the EU through their effect on bilateral trade flows. They consider a sample of exporter-goods pairs and compare bilateral trade flows of those that are subject to sanctions with those that are not to test the hypothesis that an exporter-good pair is affected by the sanctions regime. Using a difference-in-difference approach, they find that the Russian sanctions imposed on food imports resulted in an 8 times more decline in trade flows than those imposed by the EU and the US on the exports of extraction equipment. They attribute these findings to the limited retro-activity of Western sanctions, which allowed exemptions for exports made pursuant

[3] In Felbermayr et al. (2021), the further study the contributions in the analysis of sanctions in Economics and Political Science.

to contracts enacted prior to 2014. Ahn and Ludema (2020) also employ a difference-in-difference approach to compare the financial performance of targeted Russian firms to their non-targeted peers before and after the imposition of sanctions.[4] They find that targeted firms lost 1/4 of their operating revenue, over 1/2 of their asset value, and about 1/3 of their employees after being targeted by sanctions. They also find that firms that are in sectors more reliant on imported services from the West are the hardest hit. However, firms that were publicly designated as "strategic" were shielded by the Russian government, thus making them relatively immune to the effects of the sanctions. Gaur et al. (2023) study the response of targeted versus non-targeted Russian between 2014 and 2020 using longitudinal data from the Orbis database provided by Bureau van Dijck and do not find persistent negative consequences for employment or turnover by Russian firms. Using an institutional perspective, they document how Russian firms adapted to the targeted sanction to negate their effects. Crozet and Hinz (2020) use structural gravity model together with bilateral monthly UN Comtrade trade data to evaluate the export losses from all trading partners - nor just sanctioning ones. Using a counterfactual general equilibrium analysis, they estimate the loss to all major economies including 37 sanctioning countries, Russia, and 40 other largest exporters between December 2013 and December 2015 to be $96 billion, with 50% borne by the Russian Federation. The losses in exports in sanctioning Western countries amount to around $42 billion, of which 92% is incurred by EU countries. They use French customs data at the firm- and product-level to show that changes in country risk affecting international transactions due to sanctions are the transmission channel for the decline in exports of non-embargo products to Russia by sanctioning countries. Gorg et al. (2023) exploit German data on firms at the firm-product-destination level and employ a difference-in difference methodology to understand the differential response of German exporting the same product to Russia and other destination countries to the sanctions associated with the annexation of Crimea in 2014. They show significant effects on the extensive margin of trade with Russia, i.e. firm entry, continuance or exit from the Russian Market, as well as on the intensive margin, i.e. export values, quantities and prices. They find that the impact of firm performance is heterogeneous in that firms highly dependent on Russia as an export market tend to suffer declines in sales and employ-

[4]They make use of the firm- and individual-level data from the BvD Orbis and LexisNexis World Compliance database to identify a group of sanctioned firms and their subsidiaries and a control group of non-sanctioned firms. For this purpose, they collect the home country and sector of business operation of the sanctioned companies in the BvD database as well as a set of non-sanctioned strategic companies which they conjecture may have been shielded from the full effect of sanctions.

ment but the overall effect is modest. Hinz and Monastyrenko (2022) examine the impact of the embargo that the Russian Federation imposed on select food and agricultural imports from Western countries in response to previously imposed economic sanctions against it. They find evidence for the direct effect on monthly consumer prices with a difference-in-differences approach in that the embargo caused prices of embargoed goods to rise by up to 7.7% – 14.9% in the short run and by on average 2.6% – 8.1% until at least 2016. Their results further suggest the shock was transmitted to non-embargoed sectors through domestic input-output linkages. They also construct a general equilibrium Ricardian model of trade with input-output linkages and goods that are tradable, non-tradable or embargoed. According to their counterfactual analysis, the overall price index in Russia is predicted to have increased by 0.33% and welfare to have declined by 1.84% due to the embargo.

Besedes et al. (2017, 2018) examine the impact of the imposition of financial sanctions on German firms using data on balance of payments transactions. The two papers differ in the length of the samples and the coverage of firms affected by sanctions. Using data on monthly balance of payments transactions, Besedes et al. (2018) examine the impact on non-financial German firms between 1999-2014 and find that German financial activities are significantly reduced after the imposition of sanctions at the extensive margin, with fewer firms and asset classes undertaking cross-border activities. However, they find less of an impact on total financial flows. They also find that firms doing business with sanctioned countries tend to be disproportionately large, making them largely immune to the loss of business with individual partners. Third, they find that firms affected by sanctions tend to increase their activity with non-sanctioned countries, some of which have trade ties with the sanctioned country. Fourth, they find no effect of sanctions on aggregate measures of firm performance such as employment. While they conclude that sanctions impose minor economic costs to the sanctioning country, their analysis does not include the more comprehensive set of sanctions imposed during 2022-2023.

In a more recent analysis, Mamonov and Pestova (2022) examine the aggregate impact of three waves of financial sanctions imposed on the Russian economy and on different cross-sections of the population.[5] The authors identify sanctions news shocks from shocks to Russia's credit spread and

[5] These sanctions correspond to the sanctions imposed due to the annexation of Crimea and the hostilities in eastern Ukraine, the renewal and extension of the existing sanctions in 2017 in response cyber-attacks, election interference and support for the Syrian regime, and the third unprecedentedly broad set of sanctions in response to Russia's invasion of Ukraine in February, 2022.

international credit supply using sign restrictions from a structural VAR (SVAR), after controlling for the confounding effects of commodities terms-of-trade (through changes in the oil price) and the domestic monetary policy stance.[6] While the predicted effects of the first two waves of sanctions are small, the third wave is predicted to lead to output declines equal to those experienced in the transition to a market economy in 1992 and during the Russian debt crisis of 1998.

Itskhoki and Mukhin (2022) study the mechanisms through sanctions may lead to appreciation or depreciation of the exchange rate. They create an open economy model with home and foreign goods and market segmentation in the market for home and foreign currency deposits that allow for different home interest rates.[7] They show that factors such as the freezing of government foreign exchange reserves, excluding major banks and corporations from international capital markets, and a threat of blocking commodity exports were associated with a sharp depreciation of the ruble while tougher sanctions on Russia's imports together with capital controls and financial sanctions led to a capital inflow and hence, were associated with an appreciation of the ruble. They conclude that there is no one-to-one relationship between the welfare losses associated with sanctions and the behavior of the exchange rate.

Mamonov et al. (2021) examine the behavior of Russian banks subject to a set of financial sanctions that were phased in between 2014 and 2019. Using a matching estimator, they create a set of non-sanctioned similar in characteristics to the sanctioned ones and estimate both the direct and informational effects of sanctions by potentially targeted banks. They show that targeted (but not yet debt-sanctioned) banks decreased their asset holdings in foreign banks immediately but initially increased their borrowing whereas targeted (but not yet asset-sanctioned) banks decreased both their international assets and international borrowing. While the targeted banks faced deposit withdrawals when sanctions against them were announced, the government provided support to prevent bank failures.[8] Drott et al. (2022) use information from TARGET2, the real-time gross settle-

[6] They use a high frequency identification scheme to generate a series on the sanctions news shocks that accounts for news about sanctions announcements embodied in the yield-to-maturity of Russia's US dollar denominated sovereign bonds together with the realizations of the international credit supply shocks and examine its effects on a variety of macroeconomic series.

[7] They allow a precautionary demand for foreign currency deposits by including for a term in households' utility functions that depends on such foreign currency deposits. They also create a composite sector combining the government, production and financial sectors, noting that the major share of employment in tradables and non-tradables is indirectly or directly in the public sector and the major financial institutions are government banks.

[8] They also show that sanctioned banks engaged in credit reshuffling in the sense that they reduced lending to non-financial but increased lending to households, thereby yielding the absence of an aggregate effect on the Russian economy.

ment system owned and operated by the Eurosystem, to examine the effects of financial sanctions imposed by the European Union (EU) on individual bank accounts in Russia following the country's military interventions in Ukraine in 2014 and 2022. They find that financial sanctions substantially reduce inflows to and outflows from sanctioned Russian bank accounts and that the estimated effect of the 2022 sanctions on financial flows is stronger than that of the 2014 sanctions.

2.2 The sanctions of 2014

As more recent studies have shown, three waves of sanctions were imposed, in 2014, 2017 and 2022, respectively. The last set of sanctions were unprecedented in scope, involving freezes on half of the international reserves of the Central Bank of Russia, assets bans on individuals and corporate entities, bans of state banks and politically connected private banks from the SWIFT payment system, bans on Russia's exports and imports, and so on.[9]

The sanctions regime instituted against Russia in 2014 by the US, the EU, Canada and their allies initially included sanctions against individuals and entities such as travel bans and asset freezes followed by sectoral sanctions on companies representing defense industry, raw materials and financial sectors. The initial set of sanctions were imposed in March 2014 by the U.S in coordination with the EU while the level of the sanctions was intensified in July 2014 after the downing of Flight MH17/MAS17 over eastern Ukraine, where systematically important companies and banks in Russia were targeted. These restricted lending for major public and private banks and technology transfer and cooperation with Russia's oil and gas companies.[10] As an example, Sberbank, which is Russia's largest bank serving half of its population and a million businesses, could no longer raise medium and long-term finance in Europe.[11] Likewise, ExxonMobil was forced to withdraw completely from its collaboration with Rosneft in all its Arctic licenses; see Henderson (2015). Russia responded by announcing a set of counter-sanctions with a ban on food imports from Western

[9] See EC (2022) or Treasury (2022).

[10] According to the US Treasury Department's Office of Foreign Assets Control (OFAC), the first set of sanctions are denoted as sanctions against Specially Designated Nationals and Blocked Persons (SDNs) and while the second set involve sanctions prohibiting lending, investment, and trading with entities on the Sectoral Sanctions Identifications (SSI) list. See Welt et al. (2022) for a comprehensive list of these sanctions.

[11] By April, 2022, Sberbank and its 42 subsidiaries were facing fully blocking sanctions, which would freeze their assets in the West and completely prevent transactions with the exception of financial operations for the trade in food and fertiliser.

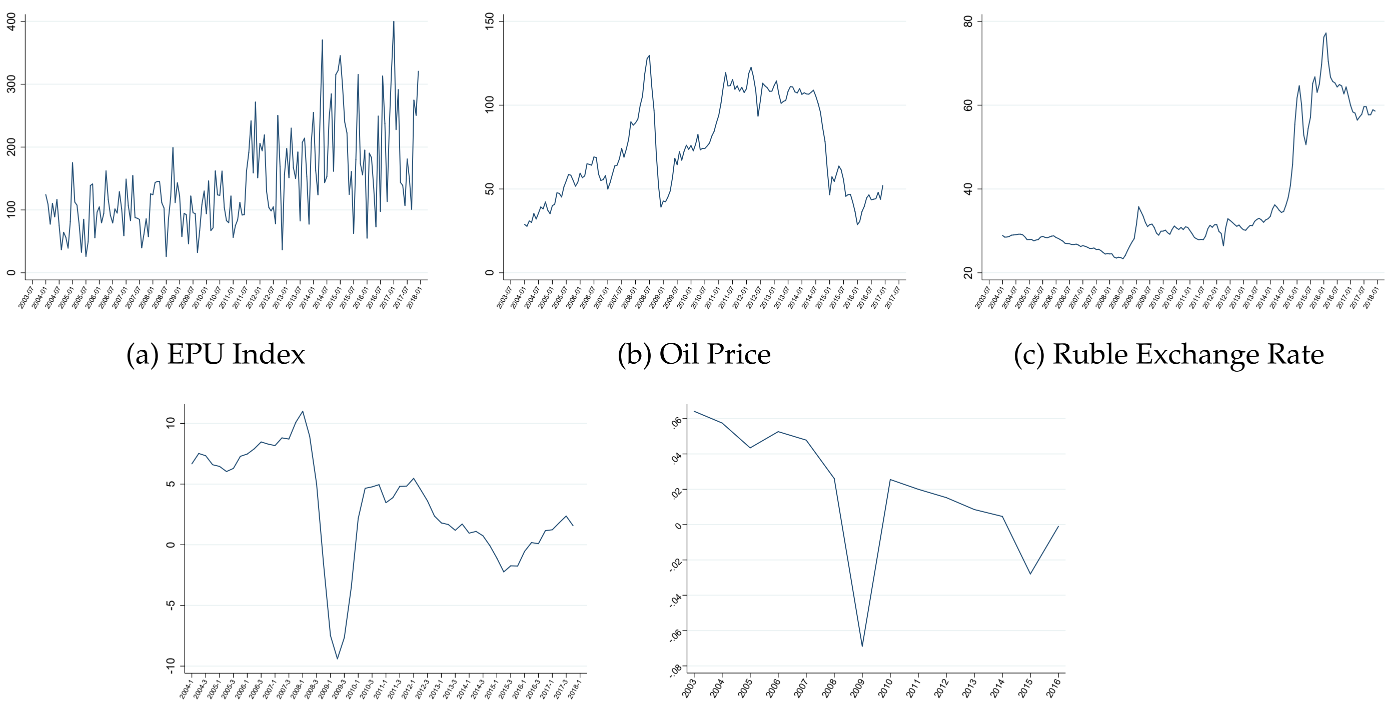
countries in August 2014. While the EU sanctions were less stringent, allowing companies to proceed with contracts that were already announced, many EU companies appeared reluctant to do so in the face of remaining geopolitical tensions, especially in investment for the high technology production of oil.

Concurrently with the events surrounding the Ukrainian crisis of 2013-2014, oil prices started declining by mid-2014, around the same time as the first round of sanctions. The Russian economy is known to be one of the most dependent economies on the production and exports of natural resources, especially oil. As the oil price fell from highs of over $100 per barrel during early 2014 to the low $30's by the beginning of 2016, the value of the Russian ruble also plunged against major currencies by more than 50% during the same period.[12] The value of the ruble against other major currencies gradually stabilized at a lower level after the Central Bank of Russia transited to a floating exchange rate regime in November 10, 2014 and increased the Russian overnight interest rate, the ROUNIA, from a stable value of 8.5% to 17% in December 16, 2014. After a strong rebound from the Global Financial Crisis (GFC), GDP growth began to stall, eventually turning negative in 2015 and 2016. Economic policy uncertainty as measured by the EPU index from Baker et al. (2016a) also skyrocketed during this period (Figure 1).[13] Another feature of the Russian economy during this period is the slowdown of TFP growth rates that have been ongoing since the mid-2000's. As Panel (e) of Figure 1 shows, TFP growth displays a declining trend throughout the sample period. It falls dramatically during the 2008-2009 Global Financial Crisis. While it partially recovers by 2010, the onset of sanctions in 2014 is again associated with a sharp decline in the growth rate for the Russian economy.

[12] For reasons behind the oil price decline, see Stocker et al. (2018).

[13] The EPU for Russia is constructed from searches based on the Russian financial newspaper Kommerstant's own online archive from 1992 onward; see Baker et al. (2016b).

Figure 1: Macroeconomic indicators for Russia



(a) EPU Index

(b) Oil Price

(c) Ruble Exchange Rate

(d) GDP Growth

(e) TFP Growth

SOURCES: The EPU Index is measured as the monthly Economic Policy Uncertainty index for Russia; see Baker et al. (2016a). Oil price: Average World Price: Crude Oil: Urals: USD/barrel: CEIC Data. Nominal exchange rate: Organization for Economic Co-operation and Development (OECD): Main Economic Indicators. Real Gross Domestic Product (GDP): OECD, Leading Indicators OECD: Reference Series: GDP: Original Series for the Russian Federation. Total Factor Productivity (TFP): University of Groningen and University of California, Davis, Total Factor Productivity at Constant National Prices for Russian Federation. The latter three series are obtained from FRED, Federal Reserve Bank of St. Louis.

A set of studies have sought to identify the effects of sanctions and the other concurrent developments on the Russian economy using macroeconomic data. Dreger and Kholodilin (2016) create a sanctions news index for the Russian economy based on a trade-weighted sum of the different types of sanctions implemented against Russian entities, and estimate a VAR with oil prices, the ruble exchange rate and the sanctions news index to argue that the decline in the price of oil, not sanctions, was responsible for the ruble devaluation. However, they find that sanctions increased the conditional volatility of the ruble exchange rate. Gurvich and Prilepskiy (2015) study the financial channel of sanctions on the Russian economy that are associated with limits on foreign borrowing.[14] They

[14] They study both direct effects of sanctions, which correspond to restrictions placed on foreign borrowings of Russian issuers and indirect effects, which correspond to higher financial risk due to increased geopolitical tensions, the expectation of future sanctions as well as restrictions on capital transactions by Russia itself.

conclude that sanctions led to a negative effect of $280 billion on gross capital outflow for 2014–2017 but a net negative effect on capitals inflows of $160–170 billion due to decreased capital outflows by Russian companies. They also find that the impact of oil price decline was much larger on the Russian economy than sanctions. Ankudinov et al. (2017) examine the impact of sanctions on the extreme movements and heavy-tailedness properties for Russian stock indices returns. They find evidence of a statistically increase in volatility. However, they conclude that the increase in heavy-tailedness cannot be linked directly to sanctions, instead deriving from increased geopolitical risks and oil price volatility. In the analysis that follows, we seek to examine the heterogeneous effects of these events on investment behavior by Russian firms. In terms of the behavior of TFP growth, Drobyshevsky et al. (2018) cites several reasons for the decline in TFP growth, including the end of the high growth era associated with the transition from a planned to a market economy from the 1990's to the 2000's as well as the lack of progress in institutional reforms. However, they also note that "an additional factor in the decelerating TFP trend since 2014 has been sectoral and financial sanctions imposed on Russian companies and banks." They further note that the effects of such sanctions may have been compounded by tightened financial conditions due to credit rationing and higher interest rates together with the higher costs of imported inputs due to ruble devaluation. These, in turn, may have interacted with sanctions to reduce investment rates for Russian firms.[15]

3 Data

3.1 Firm-level Data

In our study, we use the Ruslana historical product compiled by Bureau van Dijk (BvD). The Russian data set obtained from this product provides comprehensive coverage of firms operating in Russian non-financial sector, accounting for 70% of the gross value added reported by the Russian statistical agency Rosstat in 2014.

The data set in our analysis covers not only large publicly-listed firms, as in most of the literature

[15] In a related analysis, Wildnerova and Blöchliger (2020) examine the firm-level factors behind the macroeconomic productivity slowdown for Russia over the sample period 2003-2014 using a firm-level data set similar to ours but they do not examine the behavior of investment. However, they argue that "the conspicuous fall [in productivity] in 2014 could be related to the collapse of oil prices and sanctions and counter sanctions following the Ukraine crisis."

studying investment and employment, but also privately-held firms, ranging from micro enterprises and SMEs to large firms. As illustrated in Table B.3 in Appendix Section B.3, it mimics the firm-size distribution in the SME sector of the Russian economy.

Following Díez et al. (2021); Kalemli-Ozcan et al. (forthcoming); Gopinath et al. (2017), we apply data construction and cleaning steps as described in Appendix Section B.1. We exclude firms with less than three consecutive years of data and retain firms that have a presence for at least three years before the sanctions regime was instituted and at least one year while the sanctions regime was in place. This results in an unbalanced panel of Russian non-financial sector, representing firms of various sizes and ages. The panel structure of this unbalanced sample is illustrated in Figure B.2 in Appendix Section B.2.

Table 1: SUMMARY STATISTICS, 2004–2016

Variable	Obs.	Mean	Std. Dev.	Min.	Median	Max.
CAPEX/Assets	336,321	0.0492	0.1258	-0.1446	0.0283	0.4685
Cash flow/Assets	336,321	0.0616	0.2034	-0.5649	0.0472	0.5791
Sales growth	336,321	0.0622	0.6621	-0.9879	0	1.9318
FX debt/Assets	336,321	0.0286	0.0469	0	0.00002	0.1696
Financial leverage	336,321	0.2721	0.5359	0	0.0002	3.1324
Leverage	336,321	0.7479	0.6293	0	0.7591	2.7531
Debt burden	336,321	0.0462	0.1629	0	0	0.9076
Size	336,321	15.8323	4.7997	8.0681	15.7845	26.8656

NOTES: Table 1 reports summary statistics of the firm-level variables used in our empirical analysis. Appendix Section B.4 for the detailed variable definitions.

Table 1 provides summary statistics on the main firm-level variables used in our empirical analysis. These variables are winsorized at the 5% level such that their kurtosis falls below a threshold of 10. We observe that gross investment rate, defined as capital expenditures (CAPEX) scaled by beginning-of-year book value of total assets, has a mean of almost %5 and a median of %2.8. The gross investment rate has a standard deviation of of 0.126, showing important variation in our sample. Sales growth which is used to capture profitable growth opportunities has a mean of 0.06 and standard deviation of 0.6621, and varies between a minimum of -0.9879 and a maximum of 1.9318. This suggests that there is significant variation in the growth opportunities for Russian non-financial firms, which is likely to affect their investment performance over the sample period. Mean cash flow relative to assets is positive at 0.0616 with a standard deviation of 0.20134. Financial leverage has mean of 0.2721 and varies between 0 and 3.1324 while the ratio of FX debt to assets is 0.0286 on average with a maximum value of nearly 0.17. Leverage which is used to capture all types of debt has a higher mean of 0.748, suggesting that non-financial debt including trade credit constitutes a significant portion of the debt of an average Russian non-financial firm. Debt burden has a mean of 0.046, implying that financial cost accounts for 4.6% of gross revenue of an average firm in our sample. Firm size, proxied by the logarithm of firm's total assets, has a mean of 15.83 with much variation across firms and over time.

3.2 Investment behavior in the Russian Non-financial Sector

Figure 2 displays investment behavior of non-financial sector in Russia over the period 2011-2016 comparing the pattern of "aggregate" gross investment rate from OECD National Accounts Data shown in Panel (a) to the pattern of "aggregated" gross investment rate from the Ruslana data set shown in Panel (b).[16,17]

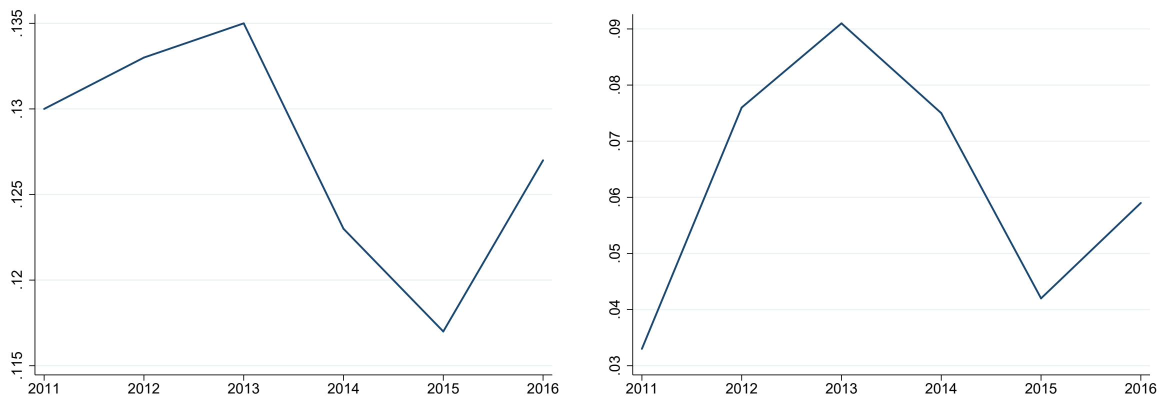
In Panel (a) of Figure 2, it shows that aggregate gross investment rate is increasing up until 2013, when it reverses itself and declines until 2015. While the Ukrainian crisis and the onset of sanctions associated with the annexation of Crimea cause a large drop in the aggregate investment rate displayed in in Panel (a) Figure 2, the fact that it starts declining by 2013 may reflect some of the factors that also lead to declines in TFP following the GFC. These include the end of sources of growth associated with the transition from a planned economy to a market economy as well the failure to make substantive institutional reforms during this period. As a result, the Ukrainian crisis and the onset of sanctions in 2014 appears to cause whatever gains followed by GFC that had been obtained up to 2012 by Russian firms to dissipate afterwards. In Panel (b), we observe a similar behavior based on aggregated gross investment rate compiled from the sample of Russian non-financial firms.

[16]The sample of Russian non-financial firms used in our analysis covers the period 2004-2016, while the National Accounts Data provided by the OECD starts from 2011. Therefore, we limit our comparison exercise to the period beginning in 2011.

[17]While the sample obtained from the Ruslana data set offers a comprehensive representation of the Russian economy as illustrated in Table B.3 in Appendix Section B.3), it is not based on census data. Consequently, it does not include the large Russian companies that could significantly influence the aggregated values. Therefore, instead of comparing the ratios based on those aggregates, we focus on analyzing the time series patterns of gross investment rate.

Figure 2: Evolution of Corporate Investment, 2011–2016

(a) **Gross Investment-GDP** (b) **Gross Investment Rate**



NOTES: This figure displays "aggregate" gross investment rate and "aggregated" gross investment rate for non-financial sector in Russia in comparable fashion. In Panel (a), we plot "aggregate" gross investment rate, defined as gross fixed capital formation divided by total economy GDP in OECD National Accounts Database. To calculate gross investment rate plotted in Panel (b), using the sample of Russian non-financial firms extracted from ORBIS database, we aggregate firm-level CAPEX (Gross Investment), defined as the fixed assets minus lagged fixed assets plus depreciation, and total assets for non-financial sector and take the ratio of aggregated CAPEX to aggregated assets.

3.3 Sector-level data

To measure the sector-level proxies used controls in the estimation of Equation (4) for capturing heterogeneous responses of non-financial firms' investment in Russia to the sanctions regime, we utilize the 2018 edition of OECD Inter-Country Input-Output (ICIO) Tables. The ICIO Tables provides national accounts data at an annual frequency for 69 countries (with the 69th country representing the rest of the world) from 1995 to 2015.[18] This internationally harmonized data provides sector-level information for each country, employing an aggregation of 2-digit ISIC Revision 4 codes to represent 36 sectors, which are labeled by the OECD ISIC Codes.

For any industry s in a given country c, the output serves either as a final good or an intermediate good. To represent this, the ICIO Tables are divided into two segments. The input-output segment consists of a 2484×2484 matrix, where the on-diagonal blocks represent domestic transaction flows of intermediate goods and services across industries, and the off-diagonal blocks represent inter-country flows of intermediates via exports and imports. The final demand segment consists of 2484 entries for 36 industries across 69 countries. For any industry-country combination, final demand

[18] The corresponding data is publicly available at https://stats.oecd.org/Index.aspx?DataSetCode=IOTSi4_2018.

corresponds to the total expenditure on goods and services.

4 An Empirical Framework

In this section, we introduce an empirical framework designed to investigate the impact of sanctions on the investment behavior of non-financial firms in Russia. Our aim is to identify the impact of sanctions on firm-level investment after controlling for a variety of geopolitical and macroeconomic phenomena that may also affect the firm's behavior.

For this purpose, we begin by examining the pre- and post-sanctions regime's unconditional mean gross investment rates in our sample. Second, we extend this analysis to a multivariate setting to account for firm characteristics and confounding macroeconomic factors. Third, we exploit cross-section dispersion in firm-level exposure to the imposition of sanctions to capture the heterogeneous responses of investment by non-financial firms in the Russian sample. Lastly, we conduct two placebo tests to address any potential identification concerns and perform various estimations to check the robustness of our findings.

4.1 Sanctions and investment behavior of Russian non-financial firms

Table 2 shows the unconditional mean of gross investment expenditures of the firm as a ratio of its total assets in the pre- and post-sanctions regime. Panel A of this table summarizes the average investment response of Russian non-financial firms in years prior to sanctions being imposed (2004-2013) versus in years after sanctions were imposed (2014-2016). From Panel A we observe that the investment rate declines by 0.025 during the sanctions regime, representing almost 50% drop in the unconditional mean investment rate relative to that in non-sanction years and that this difference is statistically significant at 1% level. Panel B shows investment rate dynamics around the sanctions regime. We observe that the unconditional mean of the gross investment rate to total assets declined from 4.2% and 4.6% in 2012 and 2013 to 2.9% in 2014 and that this decline persisted in 2015 and 2016, providing a preliminary evidence on the dampening effect of sanctions on capital expenditures by Russian non-financial firms.

Table 2: DESCRIPTIVE STATISTICS

Panel A: Mean Investment Rates in Sanction vs. Non-Sanction Years					
Sanction Years	0.028				
Non-sanction years	0.053				
Difference	-0.025				
t-test (t-stat)	-45.08				
Panel B: Mean Investment Rates Around Sanction Years					
Year	2012	2013	2014	2015	2016
Investment Rate	0.042	0.046	0.029	0.026	0.029

NOTES: Table 2 reports the unconditional means of I/TA, where I/TA is the firm's capital expenditures-total assets ratio.

4.2 A reduced-form investment equation

We next investigate post-sanctions investment patterns of Russian non-financial firms in a multivariate setting by considering a classical reduced-form investment model that allows for controlling firm characteristics and confounding macroeconomic factors assumed to be important in explaining firm investment behaviour in recent papers in the relevant literature (Gulen and Ion, 2015; Baker et al., 2016a; Dejuan-Bitria and Ghirelli, 2021; Kalemli-Özcan et al., 2022).[19]

The baseline model we assume may be written as follows

$$\mathrm{I}_{i,t}/\mathrm{TA}_{i,t-1} = \beta_1 \mathrm{SR}_t + \beta_2 \mathrm{X}_{i,t-1} + \beta_3 \mathrm{Macro}_{t-1} + \mu_i + \epsilon_{i,t}, \quad (1)$$

where i and t index firm and year, respectively. The dependent variable, $\mathrm{I}_{i,t}/\mathrm{TA}_{i,t-1}$ is the gross investment rate defined as CAPEX scaled by beginning-of-year book value of total assets for firm i at date t.[20] The explanatory variable of interest is the sanctions regime dummy denoted by SR_t, which takes a value of 1 for any firm-year for $t \geq 2014$ during sanctions regime and 0 otherwise.[21]

The vector $\mathrm{X}_{i,t-1}$ contains a set of firm-level time-varying variables that capture different firm-

[19] Bloom et al. (2007) and Bond and Lombardi (2006) consider an error correction model of investment using plant-and firm-level data disaggregated by type of investment. While we seek to understand the impact of sanctions directly, their interest is to quantify the dampening effect of uncertainty on investment behavior.

[20] Note that in the structural analysis, we work with the series of investment rate i.e., I/K defined as gross investment scaled by beginning-of-year book value of tangible fixed assets (capital stock). Therefore, by construction, the average values of the series used in the empirical analysis is lower than these series.

[21] The use of sanctions regime dummy to capture the impact of the imposition of sanctions in 2014 and beyond is also followed by Gorg et al. (2023), who capture the political uncertainty associated with the Crimea conflict with a time dummy for December 2013 as well as the subsequent imposition of sanctions with another time dummy for August 2014.

characteristics that can explain the variation observed in a firm's gross investment rate. These variables include the ratio of cash flow to total assets, sales growth and debt burden that we use to control for firm's profitability, future growth opportunities, and firm's financial health, respectively. $X_{i,t-1}$ also contains other relevant firm characteristic such as firm size that also might have an impact on investment decisions (i.e. firm size might capture the degree of financial constraints in a way that cash flow and debt burden do not (Fazzari et al. (1988))).

In the given specifications of Equation (1), we cannot include time fixed effects because time fixed effects would otherwise mechanically absorb all explanatory power of the variable of our interest, the sanctions regime dummy. Hence, we use two variables to explicitly control for possible confounding macroeconomic factors denoted by Macro_{t-1}. First, we include annual GDP growth, measured as the percentage change in real GDP in the year prior to the investment decision to control for any variation observed in aggregate demand conditions in business cycles. Second, we include the EPU index for Russia created by Baker et al. (2016a) to control for the many uncertainty-inducing events that happened before the sanctions regime such as the 2008 Georgia invasion of Russia, GFC, and geopolitical tension in the region as well as the 2014 Ukraine invasion of Russia, oil price decline and Ruble devaluation that happened concurrently with the imposition of sanctions by the West.

Further, we include firm-fixed effects represented by μ_i in Equation (1) that control for omitted variable bias arising from unobserved time-invariant heterogeneity at the firm-level.[22] Hence, we are better able to identify the individual effects of firm-level time-varying characteristics on investment by exploiting the variation of corresponding firm-level variables over time. Observations of the same firm may be correlated over time, hence we cluster standard errors at the firm-level to correct for potential serial correlation in the error term, $\epsilon_{i,t}$.

Table 3 shows the results of estimating Equation (1) using the unbalanced panel data of Russian non-financial firms. Note that we estimate Equation (1) with all control variables lagged one period to mitigate any potential endogeneity issues associated with reverse causality. In this table column (1) reports the regression of investment on the sanctions regime dummy alone. The following columns add firm fixed effects, the proxies controlling for firm-level characteristics and confounding

[22] μ_i is not observable to econometricians and cannot be controlled for by the explanatory variables constructed using any firm-level data available, therefore, we estimate a Fixed Effects model that eliminates μ_i by demeaning the variables using the *within* transformation.

Table 3: BASELINE INVESTMENT REGRESSIONS

Dependent variable: I/TA

	(1)	(2)	(3)	(4)	(5)
SR	-0.02240***	-0.03187***	-0.03087***	-0.02935***	-0.01571***
	(0.00055)	(0.00086)	(0.00087)	(0.00086)	(0.00134)
Sales Growth			0.00353***	0.00526***	0.00389***
			(0.00051)	(0.00051)	(0.00052)
Cash Flow			0.01018***	0.01849***	0.01695***
			(0.00220)	(0.00218)	(0.00218)
Debt Burden				-0.03428***	-0.03357***
				(0.00370)	(0.00368)
Size				-0.01748***	-0.01722***
				(0.00048)	(0.00047)
EPU					-0.00021***
					(0.00002)
GDP Growth					0.00125***
					(0.00006)
Firm FE	no	yes	yes	yes	yes
Obs.	226,760	206,569	206,569	206,569	206,569
R^2	0.0058	0.36	0.36	0.37	0.37

NOTES: Table 3 reports the results of estimation of Equation (1). I/TA is the firm's capital expenditure-total assets ratio. The variable SR is a sanctions regime dummy variable which takes a value of 1 for $t \geq 2014$ and 0 otherwise. See the Appendix Section B.4 for variable definitions of firm-level controls. Heteroskedastic-consistent standard errors clustered at firm level are reported in parentheses.***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

macroeconomic factors. Across all specifications in this table, consistent with the above-mentioned preliminary evidence, the sanctions regime leads to a significant decline in the conditional mean gross investment rate. Columns (3)–(4) show that the coefficients on traditional determinants of investment are found to be statistically significant and have the expected sign in line with the literature. Specifically, holding everything else constant, on average, current and future profitability affect firms' investment rate positively. In contrast, the negative coefficient on the debt burden suggests that the gross investment rate of the typical firm in our sample is negatively affected by a deterioration observed in its financial health. As expected, firm size enters the estimation with a statistically significant and negative sign, capturing the presence of decreasing returns to scale in investment. In column (5), our findings remain robust when we account for potential confounding macroeconomic factors, ensuring that the observed reduction in investment is primarily driven by the imposition of sanctions rather than other uncertainty-inducing events.

The reduction in gross investment rates associated with sanctions is economically meaningful.

As shown in columns (1)-(5), the estimated reductions in average gross investment rates range from 0.0157 to 0.0319, depending on the specification. The estimates presented in column (5), which serve as the baseline specification for the remainder of the analysis, indicate that, on average, investment rates decrease by 0.0157 during the sanctions regime, even after controlling for firm characteristics and macroeconomic factors. In terms of magnitude, this coefficient represents a substantial 29% reduction in investment rates compared to the average observed in non-sanctions years, as presented in Table 2.

4.3 Heterogeneous effects of sanctions on investment

In this section, we aim to investigate the heterogeneous responses of investment by Russian non-financial firms during the sanctions regime while controlling for the confounding effects of ruble devaluation and oil price decline. To this end, we begin by describing the measures we have developed to gauge the varying exposure of Russian non-financial firms to these confounding events during the sanctions regime. Next, we outline the estimation equation designed to account for the role of these confounding events in explaining the variation in post-sanctions investment rates of Russian non-financial firms. Finally, we interpret the findings.

Russian firms with strong supply-chain relationships with various sectors of sanctioning economies might witness substantial reductions in their imported inputs, potentially affecting their investment behavior. To explain the observed variations in firms' investment rates after the imposition of sanctions, we develop a sanctioned trade linkage measure, which exploits sectoral variations in trade linkages. This measure quantifies the extent to which Russian non-financial firms in different sectors are connected to countries imposing sanctions. For any sector-year combination, we measure the sanctioned trade linkage as

$$\text{SancTradeLink}_{s,t} = \sum_{c=1}^{n} \frac{\text{Imported Inputs}_{c,s,t} \times \text{Sanc}_{c,t}}{\text{Total Imported Inputs}_{s,t}}, \tag{2}$$

where $\text{Imported Inputs}_{c,s,t}$ refers to intermediate goods that are bought from the sector s of corresponding country c; $\text{Total Imported Inputs}_{s,t}$ refer to total inputs bought from abroad in sector s in the given year t, respectively. $\text{Sanc}_{c,t}$ is a country-level dummy that takes on a value of 1 if the given country has introduced sanctions on the Russian economy from 2014 onward and 0 otherwise.[23]

The advent of sanctions in Russia in 2014 is accompanied by a large oil price decline. This may affect the investment behavior of firms through various channels. To the extent that changes in the oil price create heterogeneity across different industries, we control for any potential impact of oil price decline on investment by exploiting variation in terms of cost dependence on oil in their production process. For any sector-year combination, we proxy oil cost dependence in a sector's production with the below measure

$$\text{OilCostDep}_{s,t} = \frac{\text{Oil Input}_{s,t}}{\text{Output}_{s,t}}, \tag{3}$$

where High $\text{OilCostDep}_{s,t}$ refers to oil cost dependence of sector s of in the year t; Oil $\text{Input}_{s,t}$ and $\text{Output}_{s,t}$ refer to monetary value of oil used as input in sector s, and monetary value of output produced in sector s in the given year t, respectively.[24]

Note that we construct the above-mentioned sector-level proxies using predetermined values prior to the year 2014 when the sanctions were put in place. This ensures that the ranking of sectors in the distribution of the corresponding measure does not change with the sanctions shock. For each individual sector, we construct the time average of the values corresponding to the given sector-level measure for the 2005–2013 period. This approach enables us to assess how the imposition of sanctions affects investment for Russian firms operating in sectors with varying degrees of pre-existing sanctioned trade linkages and oil-cost dependence.

Another confounding event occurred in Russian economy during the sanctions regime is a large exchange rate devaluation, coinciding with a transition to a floating exchange rate regime. This might have different effects on the investment behavior of firms due to their exposure to foreign exchange risk. A priori, we expect that firms with greater foreign exchange debt exposure are likely to reduce their investment more during the sanctions regime, as they face more stringent financial conditions. For firms holding foreign exchange-denominated debt, an exchange rate devaluation can be seen as a negative net worth shock. It increases the value of foreign-currency denominated

[23] https://en.wikipedia.org/wiki/International_sanctions_during_the_Ukrainian_crisis#/media/File:Sanctions_2014_Russia2.svg provides the list of countries that have implemented sanctions on Russia.

[24] We construct this measure following the insights of Gogineni (2010) and Antras et al. (2012).

debt but lowers the value of assets denominated in the local currency. This tightening of financial conditions can lead to a decline in firms' borrowing and capital expenditures. In the estimation, we proxy foreign exchange debt exposure risk by the firm's foreign currency denominated debt to assets ratio, which is calculated as explained in Appendix Section B.4.

We consider the effects of these above-mentioned phenomena jointly. The reason for doing is that such factors as the ruble devaluation and the decline in the price of oil together with the sanctions regime may reflect some common underlying factors and hence, be correlated with each other. Considering them separately may lead us to attribute a greater than warranted significance to each individual phenomenon. Hence, we may view this exercise as better identifying the impact of sanctions on the investment behaviour of Russian non-financial firms by isolating it from general equilibrium-like effects.

We extend the baseline investment equation (1) to account for these effects jointly as

$$\mathrm{I}_{i,s,t}/\mathrm{TA}_{i,s,t-1} = \beta_1 \mathrm{SR}_t + \sum_{j=2}^{4} \beta_j \mathrm{SR}_t \times \mathrm{Var}_j + \gamma' \mathrm{X}_{i,s,t-1} + \mu_i + \epsilon_{i,s,t}, \tag{4}$$

where $\mathrm{I}_{i,s,t}/\mathrm{TA}_{i,s,t-1}$ is the gross investment-total assets ratio for firm i operating in sector s at date t, SR_t is a dummy variable which takes a value of 1 for $t \geq 2014$ and 0 otherwise, the vector $\mathrm{X}_{i,s,t-1}$ contains the investment predictors used in the estimation of the baseline investment equation. In all estimation specifications of Equation (4), we incorporate firm fixed effects represented by μ_i to account for firm-level time-invariant unobserved heterogeneity. In the second specification, we include aggregate variables such as EPU and GDP Growth to explicitly address potential confounding macroeconomic factors. In the third specification, we control for possible confounding macroeconomic forces implicitly by introducing time fixed effects and SR_t is absorbed by these time fixed effects.

The variable Var_j corresponds to High $\mathrm{FXDebtExposure}_{i,s}$, High $\mathrm{SancTradeLink}_s$, High $\mathrm{OilCostDep}_s$ for $j = 2, 3, 4$, respectively. Var_j is constructed as a predetermined dummy variable that takes a value of 1 for firms that are ranked above the median of the distribution of the given measure at any time during the three years prior to the year when the sanctions regime is instituted and 0 otherwise. However, it is important to note that since High $\mathrm{SancTradeLink}_s$ and High $\mathrm{OilCostDep}_s$ are predetermined sector-level dummy variables, we are unable to isolate the main (direct) effects of sanctioned trade linkage or oil-cost dependence on firm-level investment, as these effects are absorbed by firm-fixed effects.

Our identification approach is to exploit the timing of the sanctions shock as it interacts with the predetermined values of foreign exchange debt exposure, the sanctioned trade linkage, and oil cost dependence, which are not allowed to change with the shock. This identification strategy necessitates an assumption that any remaining variation in ex-post firm-specific conditions during the sanctions regime does not systematically vary based on ex-ante foreign exchange exposure risk, the sanctioned trade channel, and oil-cost dependence in production.

Table 4 presents the results of the estimation of Equation (4). Across all three specifications, we find a significant negative effect of the sanctions shock on firm-level investment that works through the sanctioned trade channel after controlling for other confounding effects. In fact, firms operating in sectors with stronger trade linkages with sanctioning countries reduce their investment rate by around 1% more than firms operating in sectors with weaker trade linkages. In terms of the coefficients of the remaining interaction terms, firms with high FX debt exposure suffer a decline in their investment rate between 0.9-1.1% relative to firms with lower FX debt exposure. The coefficient on High OilCostDep is also estimated to be negative and statistically significant, suggesting that there may exist other unobserved factors that are leading firms with high oil-cost dependence to reduce their investment rate in the face of oil price declines.

Column (1) in Table 4 further shows that the total effect of sanctions is negatively and significantly estimated in all three columns of Table 4. Since dummy variables are used to control for the confounding effects of foreign exchange exposure, sanctioned trade linkages and oil-cost dependence, the total effect of sanctions on $\mathrm{I/TA}_{t-1}$ is estimated to be negative, as captured by the sum of the estimated coefficients $\beta_1 + \cdots + \beta_4$. According to the F-tests reported at the end of Table 4, this negative effect is statistically significant. As presented in column (2) of the same table, the total effect remains negative and statistically significant even after the inclusion of time-varying aggregate factors such as the EPU index and GDP Growth which may measure the effects of the geopolitical tensions and economic policy uncertainty as well as aggregate demand conditions. In column (3), the inclusion of time-fixed effects does not change these results.

Table 4: HETEROGENEOUS EFFECTS OF SANCTIONS ON INVESTMENT

Dependent variable: I/TA

	(1)	(2)	(3)
SR × High SancTradeLink	-0.01025***	-0.01044***	-0.00939***
	(0.002)	(0.002)	(0.002)
SR_t × High FXDebtExposure	-0.00875***	-0.01043***	-0.01138***
	(0.002)	(0.002)	(0.002)
SR × High OilCostDep	-0.01576***	-0.01589***	-0.01632***
	(0.002)	(0.002)	(0.002)
SR	-0.01550***	0.01229***	
	(0.001)	(0.002)	
Sales Growth	0.00537***	0.00388***	0.00325***
	(0.001)	(0.001)	(0.001)
Cash Flow	0.01932***	0.01589***	0.01476***
	(0.002)	(0.002)	(0.002)
Debt Burden	-0.03509***	-0.03430***	-0.03333***
	(0.004)	(0.004)	(0.004)
Size	-0.01711***	-0.01659***	-0.01630***
	(0.000)	(0.000)	(0.000)
EPU		-0.00030***	
		(0.000)	
GDP Growth		0.00108***	
		(0.000)	
Total Effect: SR	-0.05026***	-0.02447***	-0.03709***
	(0.003)	(0.003)	(0.004)
F-test (p-value): SR	0.000	0.000	0.000
Firm FE	yes	yes	yes
Year FE	no	no	yes
Obs.	196,533	196,533	196,533
R^2	0.36	0.37	0.37

NOTES: Table 4 reports the results of estimation of Equation (4). I/TA is the firm's capital expenditure-total assets ratio. The variable SR is a sanctions regime dummy variable which takes a value of 1 for $t \geq 2014$ and 0 otherwise. See the Appendix Section B.4 for variable definitions of firm-level controls. Heteroskedastic-consistent standard errors clustered at firm level are reported in parentheses.***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Total effect corresponds to the marginal effect of the sanctions regime dummy calculated at a value of 1 for the each of the dummies present in the interaction.

4.4 Placebo tests

In this section, we provide a further analysis of the validity of our identification strategy regarding the impact of sanctions. First, one could argue that the negative impact captured through the sanctions variable on investment behaviour is due to an increase in political uncertainty that is war-related, and not due to the effects of sanctions per se. Second, the effect of sanctions may be due to increases in geopolitical risk that also affects investment behaviour firms operating in other neighboring countries. In this section, we conduct two placebo tests to examine the validity of these hypotheses.

4.4.1 The Russian invasion of Georgia in 2008

To test the first hypothesis, we create a counterfactual analysis of the episode in 2008 when Russia invaded Georgia. During this episode, conflict occurred but effectively no sanctions were imposed. However, our experiment falsely assumes that the Georgia invasion of Russia in 2008 resulted in sanctions by a similar set of countries that imposed sanctions on individuals and entities during 2014-2016. As in 2014, this period is also witness to ruble devaluation as well as a decline in the oil price. We consider a sample that stretches between 2004-2010 to eliminate any effects from events related to the Ukrainian crisis and allow for a false interaction term between a dummy variable for the pre- and post- 2008 period and a sanctioned trade linkage dummy in the estimation. We also allow for interaction terms between foreign exchange exposure and oil cost dependence and the dummy variable for the pre- and post-2008 period to capture any heterogeneous impacts of the confounding factors.

Table 5 shows the results of this estimation. Here we observe that the coefficient on the sanctions dummy variable, SR_t, for the post-2008 period is positively estimated in columns (1) and (2), in contrast to the results that we find for the post-sanctions 2014-2016 period reported in Table 3. We further find that the interaction terms between the SR_t dummy and foreign exchange exposure and oil cost dependence are negative and significant (as in Table 4 showing the main results with confounding effects). However, the coefficients on the interaction term SR $\times$ High SancTradeLink are positively estimated in all three specifications reported in this table and insignificant in three specifications except column (1). All of the other variables have the expected signs as in Table 3. This placebo test thus verifies the validity of our identification strategy and confirms that the negative effect on investment behavior is due to sanctions and not merely "war-related."

Table 5: PLACEBO TEST-I

Dependent variable: I/TA

	(1)	(2)	(3)
SR × High SancTradeLink	0.00755*	0.00690	0.00692
	(0.004)	(0.004)	(0.004)
SR × High FXDebtExposure	-0.02919***	-0.02922***	-0.02920***
	(0.004)	(0.004)	(0.004)
SR × High OilCostDep	-0.01629***	-0.01568***	-0.01575***
	(0.005)	(0.005)	(0.005)
SR	0.00182	0.00409	
	(0.003)	(0.003)	
Sales Growth	0.00087	0.00031	0.00047
	(0.001)	(0.001)	(0.001)
Cash Flow	0.00341	0.00181	0.00206
	(0.005)	(0.005)	(0.005)
Debt Burden	-0.02308**	-0.01960*	-0.02141*
	(0.011)	(0.011)	(0.011)
Size	-0.03858***	-0.03832***	-0.03818***
	(0.002)	(0.002)	(0.002)
EPU		0.00012*	
		(0.000)	
GDP Growth		0.00125***	
		(0.000)	
Total Effect: SR	-0.03611***	-0.03391***	-0.03804***
	(0.004)	(0.004)	(0.006)
F-test (p-value): SR	0.000	0.000	0.000
Firm FE	yes	yes	yes
Year FE	no	no	yes
Obs.	44,104	44,104	44,104
R^2	0.45	0.45	0.45

NOTES: Table 5 reports the results of estimation of Equation (4). I/TA is the firm's capital expenditure-total assets ratio. The variable SR is a sanctions regime dummy variable which takes a value of 1 for $t \geq 2014$ and 0 otherwise. See the Appendix Section B.4 for variable definitions of firm-level controls. Heteroskedastic-consistent standard errors clustered at firm level are reported in parentheses.***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Total effect corresponds to the marginal effect of the sanctions regime dummy calculated at a value of 1 for the each of the dummies present in the interaction.

4.4.2 The investment response of Kazakh firms

Table 6: PLACEBO TEST-II

Dependent variable: I/TA

	(1)	(2)	(3)	(4)	(5)
SR	-0.00920	-0.01645**	-0.00572	0.00170	-0.01102
	(0.00633)	(0.00679)	(0.00800)	(0.00812)	(0.01194)
Sales Growth			0.00659	0.01749**	0.01866**
			(0.00908)	(0.00867)	(0.00863)
Cash Flow			0.09476**	0.12055**	0.09624**
			(0.03842)	(0.03854)	(0.03869)
Debt Burden				-0.07823**	-0.07585**
				(0.02753)	(0.02722)
Size				-0.13706***	-0.13366***
				(0.01294)	(0.01286)
EPU					0.00072**
					(0.00024)
GDP Growth					0.00985***
					(0.00187)
Firm FE	no	yes	yes	yes	yes
Year FE	no	no	no	no	no
Obs.	4,323	4,323	3,117	3,046	3046
R^2	0.00049	0.31	0.34	0.40	0.41

NOTES: Table 6 reports the results of estimation of Equation (1). I/TA is the firm's capital expenditure-total assets ratio. The variable SR is a sanctions regime dummy variable which takes a value of 1 for $t \geq 2014$ and 0 otherwise. See the Appendix Section B.4 for variable definitions of firm-level controls. Heteroskedastic-consistent standard errors clustered at firm level are reported in parentheses.***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

As a second placebo test, we examine the behavior of Kazakh non-financial firms over the sample period 2004-2016. For this purpose, we estimate Equation (1) using the sample of Kazakh non-financial firms. Table 6 presents the estimation results. According to these results, we observe that the coefficients on the variables SR and EPU are both positively and insignificantly estimated, thus showing that there are no effects of events that occurred in the period 2014-2016 on the investment behaviour of Kazakh firms. These findings suggest that our identification strategy is indeed capable of distinguishing the effect of sanctions on investment behavior by Russian firms relative to other forms of uncertainty that may have affected firms in neighboring countries such as Kazakhstan.

4.5 Robustness checks

In this section, we perform several robustness checks. We start by examining whether the heterogeneous responses of investments by firms during the sanctions regime, as presented in the previous section, are not driven by any time-varying unobserved heterogeneity across firms that can be attributed to permanent differences between large and small firms.

In Table 7, columns (1) and (2) demonstrate that, on average, large firms hold higher ratios of FX debt compared to small firms. This observed variation in FX debt exposure could be attributed to various time-varying unobserved heterogeneity associated with firm size. For instance, larger firms may have easier access to FX-denominated financing due to their higher foreign currency asset tangibility developed over the years. Additionally, their stronger reputation in international capital markets or their access to information about international capital markets built over time might make it easier for larger firms to raise external finance compared to smaller firms.

Table 7: FX Debt Exposure by Firm Size

	Large	Small
	(1)	(2)
Mean	0.034	0.023
Test mean difference	(-54.38)	

Notes: Table 7 presents the mean values of the variables FX Debt Exposure measured by the ratio of FX debt to total assets, focusing on the sample of Russian non-financial firms with non-missing information on net investment to capital ratio in the period 2004–2016. Large firms are those who are ranked above the median of the distribution of firm size which is measured by logarithm of the firm's total assets. FX Debt Exposure t-statistics of the t-tests that we use to compare size-based group means are given in the parentheses.

In the first column of Table 8, we estimate Equation (4) after adding size-year fixed effects to account for systematic differences between large and small firms. The coefficient on the interaction term, denoted by β_3 in Equation (4) is found to be negative and statistically significant as in column (3) of Table 4, suggesting that any time-varying unobserved heterogeneity associated with firm size doesn't drive our results.

As a second robustness check, we include SR $\times$ Cash Flow and SR $\times$ Sales Growth in the estimation. Column (2) Table 8 demonstrates that the coefficients on the variables of our main interest, denoted by β_j for $j = 2, 3, 4$ in Equation (4), are estimated to be negative and statistically significant as in column (3) of Table 4. This finding confirms that the reduction in the gross investment rate during the sanctions regime is primarily explained by pre-existing variation in firm-level characteristics represented by foreign debt exposure, sanctioned trade linkage, and oil cost dependence, rather than variation related to a firm's profitability and growth opportunities during the sanctions regime.

Table 8: ROBUSTNESS CHECKS

	(1)	(2)	(3)	(4)
SR × High SancTradeLink	-0.00686**	-0.00754***	-0.00731***	-0.03788***
	(0.002)	(0.002)	(0.002)	(0.010)
SR × High FXDebtExposure	-0.01138***	-0.01020***	-0.01109***	-0.08197***
	(0.002)	(0.002)	(0.002)	(0.009)
SR × High OilCostDep	-0.00952***	-0.00865***	-0.00963***	-0.04365***
	(0.002)	(0.002)	(0.002)	(0.010)
Sales Growth	0.00322***	0.00276***	0.00315***	0.03365***
	(0.001)	(0.001)	(0.001)	(0.003)
Cash Flow	0.01463***	0.00969***	0.01390***	0.10772***
	(0.002)	(0.002)	(0.002)	(0.010)
Debt Burden	-0.03214***	-0.03228***	-0.03380***	-0.07653***
	(0.004)	(0.004)	(0.004)	(0.016)
Size	-0.01604***	-0.01655***	-0.01638***	-0.05792***
	(0.000)	(0.000)	(0.000)	(0.002)
Total Effect: SR	-0.02775***	-0.02639***	-0.02802***	-0.16351***
	(0.003)	(0.003)	(0.003)	(0.013)
F-test (*p*-value): SR	0.000	0.000	0.000	0.000
Sample:	All	All	All	All exc. energy firms
Dependent variable:	I/TA	I/TA	I/TA	I/K
Firm FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes
Size-year FE	yes	no	no	no
SR × Sales Growth	no	yes	no	no
SR × Cash Flow	no	yes	no	no
Obs.	196,533	196,533	192,976	192,532
R^2	0.37	0.37	0.37	0.33

NOTES: Table 8 reports the results of estimation of Equation (4). I/TA is the firm's capital expenditure-total assets ratio. The variable SR is a sanctions regime dummy variable which takes a value of 1 for $t \geq 2014$ and 0 otherwise. See the Appendix Section B.4 for variable definitions of firm-level controls. Heteroskedastic-consistent standard errors clustered at firm level are reported in parentheses.***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

We address the concern that our results may be driven by energy-producing firms which have been negatively affected by sanctions that targeted their activities, including the ban on foreign direct investments and the import of intermediate inputs in areas such as shale oil, deep water, and Arctic drilling. We deal with this concern by estimating Equation (4) after excluding "energy firms" from the sample of Russian non-financial firms.[25] Column (3) of Table 8 show that the results remain consistent, affirming that observed heterogeneous responses of investment during the sanctions regime are not specific to energy firms.

As a final robustness check, we estimate Equation (4) using the CAPEX scaled by beginning-of-year book value of capital stock (proxied by the firm's fixed assets) (I/K) as an alternative measure of gross investment rate. As presented in column (4), the coefficients on interaction terms are estimated as negative and statistically significant as in column (3) of Table 4.

5 A Structural Analysis

As the vast literature on investment under uncertainty has shown (Dixit and Pindyck, 1994; Caballero, 1999; Hassett and Hubbard, 2002; Demers et al., 2003), irreversibility and uncertainty generate the gradual adjustment of the capital stock, as observed in the data. Studying the role of uncertainty in emerging economy contexts, Carriere-Swallow and Cespedes (2013) find that emerging economies experience "a median fall in investment approximately four times as large as that found in developed countries" in response to a global uncertainty shock. Furthermore, the recovery times from such a shock are much larger for emerging economies.[26] Recently, Caldara and Iacoviello (2022) create a news-based index of geopolitical risk stretching back to 1900 and show that it displays a peak around the Russian annexation of Crimea in 2014. They also find negative effects on investment for firms exposed to the effects of such geopolitical risk as well as negative effects on macroeconomic measures of investment and employment. In terms of attributing a role for investment irreversibility, Riano (2011) argues that resale markets for existing capital are very thin in emerging-economy contexts while Gelos and Isgut (2001) argue that investment irreversibility is more important for firms in emerging economies like Colombia and Mexico than in advanced economies. Lopez-Martin (2022) introduces investment irreversibility together with exchange rate

[25] See Appendix Section B.5 for a detailed explanation of the criteria used to classify firms as "energy firms."

[26] As an example from Russia, Levina et al. (2016) study the role of regulatory uncertainty on investment decisions in Russia's regions.

fluctuations to study export dynamics for emerging economies.

In this section, we formulate a model with investment irreversibility and expandability to capture the episodes of investment and disinvestment observed for the investment behavior of Russian non-financial firms.[27] To capture the effects of economic and political sanctions imposed on various individuals and entities in the Russian Federation in 2014, we assume that such sanctions may be viewed in terms of regime shifts, where the sanctions regime corresponds to a regime with less unfavorable fundamentals than the regime with no sanctions. In this regard, our analysis follows Altug et al. (2007), who build a model with investment irreversibility and regime shifts to study the impact of political risk induced by the risk of separation of Quebec province from Canada.[28]

5.1 The model

Consider the problem of a monopolistically competitive risk neutral firm produces output using its beginning-of-period capital stock, K_t, which is predetermined at t, and a vector of variable inputs. The firm is assumed to operate both in foreign or domestic markets, and produces two differentiated goods — domestic and foreign — with a constant-returns-to-scale Cobb-Douglas production technology (Gilchrist and Sim, 2007). Although the firm produces two differentiated goods, it employs only one type of capital, K_t and the production processes of both goods are subject to the same productivity shock, A_t. The production technology also allows for domestic variable inputs such as labor, foreign variable inputs such as imported materials and energy or oil inputs. Let the production function of the firm in market $j = d, f$ be defined as[29]

$$y_{j,t} = A_t K_t^{\eta\nu_1} n_{j,t}^{(1-\eta)\nu_1} m_{j,t}^{\nu_2} o_{j,t}^{1-\nu_1-\nu_2}, \quad j = f, d, \tag{5}$$

where $0 < \eta < 1$, $0 < \nu_1 < 1$ and $0 < \nu_2 < 1$

While the firm is assumed to operate both in foreign or domestic markets, the markets that the firm operates in are assumed to be segmented so that it can charge different prices in each market

[27](Abel and Eberly, 1996) describes a two-period model of imperfect resale markets and limited expandability; for a more general version of their model, see Demers et al. (2003).

[28]See also Guo et al. (2005), who builds an irreversible investment model with regime shifts and marginal q.

[29]Lopez-Martin (2022) also considers a Cobb-Douglas production function in capital, labor and intermediate goods. However, in his setup, a CES aggregator combines inputs of domestic and foreign intermediate goods.

(Gilchrist and Sim, 2007; Lopez-Martin, 2022).[30] Let $p_{f,t}$ denote the stochastic output price denominated in the foreign currency. We assume a constant elasticity demand function. The inverse market demand function for the i^{th} firm is given by

$$p_{f,t} = (\alpha_{f,t})^{-\frac{1}{\varepsilon_f}} (y_{f,t})^{\frac{1}{\varepsilon_f}}, \tag{6}$$

Likewise, the inverse demand function specific to the domestic market for the firm is given by

$$p_{d,t} = (\alpha_{d,t})^{-\frac{1}{\varepsilon_d}} (y_{d,t})^{\frac{1}{\varepsilon_d}}, \tag{7}$$

where $\varepsilon_j < -1$ denote the price elasticity of demand and $\alpha_{j,t}$, $j = f, d$, are stochastic parameters representing the state of demand in the foreign and domestic markets, respectively.

Consider the optimal choice of variable factors, which involves static optimization under certainty. Denote by $w_{n,t}$ the variable stochastic labor input price, by $w_{m,t}$ the prices of imported inputs, $p_{o,t}$ the price of oil inputs and and by e_t the exchange rate signifying the price of foreign goods in terms of domestic goods. Let $h_t = (A_{t,\alpha_{f,t},\alpha_{d,t},w_{n,t},w_{m,t},p_{o,t},e_t,})$. We can define the short-run profit function of firm i at time t as

$$\begin{aligned} \Pi(K_t, h_t) \quad \equiv \quad & \max_{n_{j,t},m_{j,t},o_{j,t},j=f,d} \sum_{j=d,f} \{e_t^{1|j=f} p_{,t} y_{j,t} - w_{n,t} n_{j,t} - w_{m,t} e_t m_{j,t} - p_{o,t} o_{j,t}\} \\ & \text{s.t. } \; y_{d,t} + y_{f,t} = A_t K_t^{\nu_1 \eta} \sum_{d,f} \left[n_{j,t}^{\nu_1(1-\eta)} m_{j,t}^{\nu_2} o_{j,t}^{1-\nu_1-\nu_2} \right]. \end{aligned} \tag{8}$$

Here $0 < \nu_1 < 1, 0 < \nu_2 < 1$. It is possible to show that $\Pi(K_t, h_t)$ is continuous in all of its arguments, increasing in K_t, $\alpha_{j,t} j, d = f$, A_t, decreasing in $w_{n,t}, w_{m,t}$, $p_{o,t}$ and and strictly concave in K_t, α_t and A_t.[31]

We may use this framework to describe some of the channels through which variables such as the exchange rate, the oil price, and the sanctioning of the imported inputs may have on the firm's

[30] However, unlike Lopez-Martin (2022), we do not model the decision to export or not. In addition to the impact of the variable inputs, Gilchrist and Sim (2007) allows for a fixed cost of production while Lopez-Martin (2022) assumes the existence of distribution costs as a function of the domestic and foreign good. We also abstract from these considerations for simplicity.

[31] The concavity of the profit function ensures that investment is decreasing in increases in demand uncertainty, see Abel (1983) or Hartman (1972).

decisions.

The competitiveness channel of a change in exchange rates

We begin by analyzing the impact of the exchange rate e_t on the firm's profits. Note that a change in e_t has two effects. On the one hand, a depreciation of the domestic currency (represented by an increase e_t) makes imported inputs more expensive and reduces the profits of the firm for a given level of the intermediate inputs. On the other hand, an increase in e_t also makes an exporting firm better off in that it can now obtain more domestic currency for the sale of any of its goods in the foreign market.

Define $\Gamma_j = 1 - \psi_j(1 - \eta\nu_1)$, where $\psi_j = (1 + \epsilon_j)/\epsilon_j)$. The solution for the profit function is given by

$$\Pi_t \left(K_t, h_t\right) = \sum_{j=f,d} \Gamma_j S_{j,t},$$

and the firm's sales in market j at date t are given by

$$S_{j,t} = e_t^{(1(j=f)-\nu_2\psi_j)/\Gamma_j} \Psi_j X_{j,t}^{1/\Gamma_j} K_t^{\nu_1\eta\psi_j/\Gamma_j}.$$

Here $X_{j,t}, j = f, d$ denote variables that summarize the demand and productivity conditions for the firm and Ψ_j is a constant that depends on the underlying parameters of the model. Note that the real exchange rate affect profits through the term $e_t^{(1(j=f)-\nu_2\psi_j)/\Gamma_j}$. The term $-\nu_2\psi_j/\Gamma_j$ captures the effects of a depreciation currency on the value of imported inputs, which become more expensive with an increase in e_t and hence, reduce the profits of the firm. On the other hand, for any increase in e_t, the term $e^{1(j=f)}$ for $j = f$ captures the increase in revenues denominated in domestic currency that a firm operating in foreign markets can obtain, thus increasing its profits. These channels are called the competitiveness channel of a change in the exchange rate (Gilchrist and Sim, 2007), where the total effect must be determined empirically.

The sanctioned trade channel

As Halpern et al. (2015) suggests, the lack of key imported inputs may lead to a decrease in productivity as they tend to have a higher price-adjusted quality and also imperfectly substitute for domestic inputs. If imported inputs become unavailable through the sanctioned trade channel, then the effect of such sanctions will tend to depress investment for firms in a manner similar to a negative productivity shock. Studies such as Ahn and Ludema (2020) and Crozet and Hinz (2020) have examined the role of input dependence for the activities of Russian firms targeted by sanctions directly. However, there may also be indirect effects of trade-related sanctions. Hence, we expect that the level of investment by firms operating in such sectors with strong trade linkages with sanctioning countries to decline more than that by firms operating in sectors with low trade linkages with sanctioning countries such as service sectors during the sanctions regime.

We account for the impact of sanctions on the quantity of imported inputs by assuming that firms in sectors with sanctioned imported goods face an impediment to importing their desired imports when the sanctions regime is in effect. Taking into account the optimal choice of inputs by the firm, we model this by assuming that the price of imported inputs has increased as $e_t w_{m,t}/(1-s^*)$ where $0 \leq s^* \leq 1$. Here e_t is the real exchange rate or the quantity of domestic goods per unit of the foreign goods. With these definitions, the short-run profit function of firm i at time t is defined as

$$\begin{aligned}
\Pi\left(K_t, h_t\right) \quad &\equiv \max_{n_{j,t}, m_{j,t}, o_{j,t}, j=f,d} \{ \sum_{j=d,f} e_t^{1j=f} p_{j,t} y_{j,t} - w_{n,t} n_{j,t} - \frac{w_{m,t} e_t}{1-s^*} m_{j,t} - p_{o,t} o_{j,t} \} \\
&\quad \text{s.t. } \; y_{d,t} + y_{f,t} = A_t K_t^{\nu_1 \eta} \sum_{j=d,f} \left[n_{j,t}^{\nu_1(1-\eta)} m_{j,t}^{\nu_2} o_{j,t}^{1-\nu_1-\nu_2} \right] \\
&= \sum_{j=f,d} \Gamma_j S_{j,t}. \qquad (9)
\end{aligned}$$

Let $S_{j,t}$ denote the sales of the firm in market j at time t and $\Gamma_j = 1-(1-\eta\nu_1)\psi_j$ as before. Notice that restrictions on imported inputs measured through the value of s^* affect the costs for the firm. The results in Section A of the Appendix shows that variable s^* enters the expression for $S_{j,t}$ inversely so that an increase in s^* will reduce the firm's short-run profits. Hence, we may vary s^* to understand the effects of the sanctioned trade channel through its affect on the firm's sales at any date.

The impact of oil shocks

The decline in oil prices has differing impacts on the behavior of Russian firms. Since oil revenue is a large part of the Russian budget, any decline in the price of oil may be interpreted as a negative demand shock. In our subsequent analysis, we capture this effect by modelling the domestic demand shock, $\alpha_{d,t}$, in terms of real GDP for the Russian Federation. Second, since oil is an intermediate input to the production process, a decline in the price of oil will affect the costs of production of producers that have high oil-cost dependence.

In this case, the oil shock has two effects. On the one hand, a reduction in the price of oil reduces aggregate demand in the Russian economy and hence, negatively affects the state of demand affecting the firm's profits.[32] On the other hand, a reduction in the price of oil reduces the costs of production for firms that have high oil-cost dependence. Which effect dominates the impact on investment expenditures must be determined numerically. In related work, researchers have differentiated the cost- and demand-dependence of industries to oil shocks; see Lee and Ni (2002) or Gogineni (2010). In our framework, we may capture these effects jointly, as we allow for oil shocks to affect demand conditions for the firm as well as directly affecting its costs.

5.2 Investment irreversibility and expandability with regime shifts

Let R_t denote the firm's after-tax cash flow at time t and assume that the firm faces both costly irreversibility and expandability in its investment decisions.

$$R(K_t, h_t, p_t^{k,H}, p_t^{k,L}) = \Pi(K_{t+1}, h_t) - p_t^{k,H} \max\{I_t, 0\} - p_t^{k,L} \min\{I_t, 0\}, \tag{10}$$

where I_t denotes the firm's gross investment measured (in physical units) if $I_t > 0$ and its sales of capital goods if $I_t < 0$. $p_t^{k,H}$ is the purchase price of capital goods and $p_t^{k,L}$ is the resale price of capital goods. Under costly irreversibility and expandability, the purchase of capital goods exceeds the resale price as

$$p_t^{k,H} \geq p_t^{k,L}. \tag{11}$$

[32] In a different vein, (Hamilton, 1983), Hamilton (1988) argues that positive oil shocks may lead to an increase in uncertainty and the operating cost of certain durable goods, thereby lowering the demand for durable goods and investment. However, this effect is likely to be important for non-oil producers.

Letting δ be the deterministic depreciation rate, with $0 < \delta < 1$, the future capital stock is then given by $K_{t+1} = (1-\delta) K_t + I_t$. In this framework, perfect expandability occurs when the future purchase price is equal to the current purchase price of capital. However, the higher the future purchase price of capital, the lesser the expandability of the firm. An infinite future purchase price for the capital stock implies the total lack of expandability. On the other hand, the firm faces total irreversibility if resale markets are absent, i.e when $p_t^{k,L} = 0$. In this case, once the firm invests, it cannot get rid of the additional capital stock even if economic conditions warrant a lower desired capital stock. Since it cannot access resale markets, it can only allow its excess capital stock to depreciate through time.

In our analysis, regime shifts are used to model the onset of sanctions and the adverse macroeconomic conditions that accompanied them. As such, the probability of shifting from a non-sanctioned to sanctioned regime with more unfavorable fundamentals may depend on a multitude of political and economic events. In Altug et al. (2007), the properties of the electoral process in Quebec province are used to generate regime shifts that capture the risk of separation of Quebec from the Canadian federation. In the absence of such explicit approaches to calculating regime shifts, we focus on the behavior of some observed series that enable us to capture the probability of shifting to the sanctioned regime.

Recall that the firm's short-run profit function is given by

$$\Pi(K_t, h_t) = \sum_{j=f,d} \Gamma_j \Psi_j e_t^{(1(j=f)-\nu_2\psi_j)/\Gamma_j} \Psi_j X_{j,t}^{1/\Gamma_j} K_t^{\nu_1\eta\psi_j/\Gamma_j}, \tag{12}$$

where

$$X_{j,t} = \left[\frac{A_t^{\psi_j} \alpha_{j,t}^{(1-\psi_j)} (1-s^*)^{\nu_2\psi_j}}{w_{n,t}^{\nu_1(1-\eta)\psi_j} w_{m,t}^{\nu_2\psi_j} p_{o,t}^{(1-\nu_1-\nu_2)\psi_j}} \right]$$

and

$$\Psi_j = \left[((1-\eta)\nu_1\psi_j)^{\nu_1(1-\eta)\psi_j} (\nu_2\psi_j)^{\nu_2\psi_j} ((1-\nu_1-\nu_2)\psi_j)^{(1-\nu_1-\nu_2)\psi_j} \right]^{1/\Gamma_j},$$

$j = d, f$. Here $X_{j,t}$ are composite variables denoting demand and productivity conditions for the sales of the domestic and foreign good (see Section A in the Appendix). To conserve on state variables in the solution to the numerical dynamic optimization problem that we consider subsequently, we define the variable $X_t = (\tilde{X}_{f,t}, \tilde{X}_{d,t})$ where $\tilde{X}_{j,t} = e_t^{1(j=f)-(1-\nu)\psi_j} X_{j,t}, j = f, d)'$, which incorporates the effect of the exchange rate together with the remaining exogenous factors. This approach is similar to Bloom et al. (2007), who summarize demand conditions in a single index in a model with only the domestic good. Define the vector $X_t = (\tilde{X}_{d,t}, \tilde{X}_{f,t})'$. In what follows, we create a bivariate process for the elements of X_t from its underlying determinants and allow for regime shifts in their behavior.

In the model with regime shifts, firms face two regimes, the current regime 0, and a less favorable regime denoted the regime 1, a transition to which may occur with positive probability. We define regime 0 as the "no sanctions" regime for the vector of composite variables X_t while regime 1 is the "sanctions" regime in which this variable may have a worse distribution. For the purpose of our numerical analysis, we assume that X_t follows a bivariate Markov switching processes with the underlying state $s_t = 0, 1$. The probability of remaining in the current regime at time $t + 1$ is given by $\chi_{ii} = Pr(s_{t+1} = i | s_t = i,), i = 0, 1$ while $\chi_{ji} = Pr(s_{t+1} = j | s_t = i), i \neq j, i = 0, 1$ is the probability of a regime switch to regime j in period $t + 1$ given that the regime at time t is i. The condition $\chi_{10} > 0$ implies that in a case of policy shift to regime j at some time $t' < t$, there is a possibility of returning to the current regime ante at some future date. By contrast, a value of $\chi_{10} = 0$ implies that regime 1 is an absorbing state from which no return is possible.

Notice that this framework allows for the impact of sanctions together with deterioration in various fundamental variables that occurred concurrently with them into the model of costly irreversibility and expandability. First, sanctions have a direct effect on the short-run profit function of the firm through the impact of the sanctioned trade channel, where firms face an impediment to importing their desired inputs modelled here as an increase in the cost of imports as $w_{m,t}e_t/(1 - s^*)$, where $0 < s^* < 1$. However, sanctions may also affect the distribution of productivity and the state of demand for the firm. Furthermore, there exist events such as the decline in the price of oil or the ruble devaluation which occurred jointly with the onset of sanctions that also likely to affect exogenous economic conditions facing the firm.

Given these considerations, the set of composite variables that summaries the state of domestic and foreign demand, productivity and the real exchange rate defined by the elements of X_t may thus be modelled as having different distributions depending on the regime. For this purpose, assume that $X(s_t)$ evolves according the conditional density $f^{s_t}(X(s_{t+1})|X(s_t))$, given the state s_t defining the regime at time t. (Here we make explicit the dependence of X_t on the current state s_t.) The optimization problem of the firm now becomes

$$V(K_t, X_t, h_t^k, s_t = i) = \max_{I_t} \Bigg\{ \sum_{j=f,d} \Pi(K_t, X_t, s_t = i) - p_t^{k,H} \max(I_t, 0) - p_t^{k,L} \min(I_t, 0)$$
$$+\beta \sum_{j=0}^{1} \chi_{ij} \int V(K_{t+1}, X(s_{t+1}), h_{t+1}^k, s_{t+1} = j) f^{s_t}(X(s_{t+1})|X(s_t)) g(h_{t+1}^k|h_t^k) ds_{t+1} dh_{t+1}^k \Bigg\}$$
$$\text{s.t. } p_t^{kH} \geq p_t^{kL} \text{ and } K_{t+1} = (1-\delta))K_1 + I_t$$

For the model with partial irreversibility and expandability, it is only in the region $X_t^L \leq X_t \leq X_t^H$ that changes in the distribution for $\tilde{X}_t$ will affect investment. To give content to our assumption that the sanctions regime leads to changes in the distribution for X_t, we estimate a Markov switching process for X_t such that the distributions in the less favorable regime have lower means and greater volatility. As firms now assign a positive probability of facing lower or more variable states of demand or productivity or higher prices for imported inputs than in the current no-sanctions regime, downside risk increases.

For simplicity, assume that X_t^H is the value of X_t such that it is optimal not to invest at t. Under costly irreversibility and expandability, a shift in the distribution in the range $0 < X_t \leq X_{t+1}^H$ induced by the risk of sanctions will affect the decision as to whether to invest or not as well the amount invested. As the option value of waiting rises, the incidence of a binding irreversibility constraint increases: that is, X_t^H rises. Likewise, define X_t^L as the value of X_t such that it is optimal not to sell capital at t. Likewise, the decision to sell capital occurs when $X_t^L < X_t$. Any changes in the distribution increase the probability of low values of X_t induce firms to sell capital in period t. Thus, changes in the distribution for X_t in the region of values of $X_t^L \leq X_t \leq X_t^H$ affect the investment decision of the firm. Outside of this region, the firm is already investing (or disinvesting). Abel et al. (1996) call this the "Goldilocks principle" based on the notion that the news (or porridge) should be neither "too hot" or nor "too cold." Since such a change in the distribution of X_t works in the same direction by reducing the probability of high values of X_t and and increasing the probability of low values of X_t, we expect a reduction in investment and an increase in disinvestment in the regime with less favorable fundamentals.

5.3 Calibrating the model

In what follows, we seek to obtain measures of the series that summarize demand, productivity and exchange rate conditions for the Russian economy over the sample period 2003-2019. In this regard, we require measures of $(A_t, \alpha_{f,t}, \alpha_{d,t}, w_{n,t}, w_{m,t}, p_{o,t}, e_t)$. All series measured in constant prices make use of deflators with the same base year (2012=100).

The quarterly series on productivity A_t is obtained by interpolating the annual series on Total Factor Productivity for the Russian Federation measured in constant prices to the quarterly interval. In the absence of firm-level data, we proxy the domestic demand shock, $\alpha_{d,t}$, by the Gross Domestic Product for the Russian Federation in constant prices at the quarterly interval, seasonally adjusted. The foreign demand shock $\alpha_{f,t}$ is measured as world income in US dollars at the quarterly interval, seasonally adjusted (2012=100).[33]. Real hourly wages $w_{n,t}$ are derived from the quarterly series on monthly earnings for all activities in the Russian Federation divided by total hours per month (160) and converted to real terms using the GDP deflator for the Russian Federation. The unit input price $w_{m,t}$ is measured by Industrial Inputs Price Index, including Agricultural Raw Materials and Base Metals Price Indices from the IMF Primary Commodity Price (2012=100). system.[34] The real exchange rate e_t is measured from the nominal exchange rate obtained as the average of daily rates for the Russian Federation, national currency units per US Dollar, at the quarterly interval, multiplied by ratio of the US and Russian GDP deflators with base year 2012. The quarterly series on the oil price $p_{o,t}$ is derived from the monthly series on the average world price of Urals crude oil per one barrel measured in in US Dollars. We convert this price to rubles by multiplying by the ruble exchange rate and deflating by the GDP deflator for the Russian Federation.

The parameters used in the simulations are determined as follows. There are alternative estimates of the markup of price over marginal cost defined as $\varepsilon_j/(1+\varepsilon_j) = \psi_j$. Based on estimates of the sales equation, Gilchrist and Sim (2007) estimate the markup in the domestic Korean market to be 1.32 while the markup for the foreign market is estimated as 1.18. Chapter 2 of the April 2019 World Economic Outlook estimates markups for a large number of countries, including Russia, using the ORBIS dataset. They document that markups have increased by around 6% for 27 countries since

[33]These data are obtained from the World Economic Outlook (WEO) data base compiled by the IMF. https://www.imf.org/external/datamapper/NGDPD@WEO/OEMDC/ADVEC/WEOWORLD

[34]https://www.imf.org/en/Research/commodity-prices

2000. However, the increase is larger for advanced economies compared to emerging economies and that the increase has been concentrated among more dynamic and innovative firms. In what follows, we set elasticity of demand for the domestic market as $\varepsilon_d = -4$, and the elasticity of demand for the foreign market as $\varepsilon_f = -6.5$, implying markups of 1.333 and 1.182, respectively, for firms that operate in these markets. We set the share of capital in production equal to $\eta\nu = 0.2222$, which is similar to the value assumed in Gilchrist and Sim (2007). Since we allow for oil inputs, we set $\eta = 1/3$, $\nu_1 = 2/3$, and $\nu_2 = 0.25$. This implies the share of labor as $(1 - eta) * \nu_2 = 0.444$ and the share of intermediate inputs as $\nu_2 = 0.25$. Thus, the share of oil inputs is determined as $1 - \nu_1 - \nu_2 = 0.0833$.[35]

In our analysis up to this point, we modelled the impact of the exchange rate directly through its effect on profits as $e_t^{1(j=f)-(1-\nu)\psi_j}$. However, there is evidence showing that the number of firms operating in the tradables sector recorded in our ORBIS dataset decreased from 26.87% in 2003 to around 18.50% since 2015, suggesting a decline in Russian firms operating in foreign markets. Gilchrist and Sim (2007) estimate an equation for (the logarithm of) sales in each market as a function of the (logarithms) of the exchange rate e_t, the firm's capital stock $K_{i,t}$, the economic activity in each market $y_{j,t}$ and a firm-specific fixed factor. They find that the logarithm of domestic sales $s_{d,t}$ respond negatively to an exchange rate devaluation with a coefficient of -0.12 while exports $s_{f,t}$ respond positively to the devaluation with a coefficient of 0.36. [36] By contrast, the model-implied values for the coefficients on the exchange rate in firm sales using identical structural parameters in Gilchrist and Sim (2007) are -1.227 and 1.271, suggesting strong deviation between the estimated parameters and the structural parameters regarding the impact of the exchange rate. In their analysis, Gilchrist and Sim (2007) conclude that the exchange rate does not have a strong impact on the competitiveness of Korean firms. Hence, in our analysis, we modify the coefficient on the exchange rate in the expression for foreign sales by considering powers such as $b_f = 0.2$ or $b_f = 0.1$ in the specification

[35] Our specification of the production function with oil inputs deviates from some existing literature which assumes a CES aggregator between a Cobb-Douglas composite of labor and capital inputs and oil inputs (Kumhof and Muir, 2012), which we do for computational tractability. In calibrating the share of oil inputs, (Kumhof and Muir, 2012) also consider scenarios with output shares higher than historical cost shares.

[36] In this specification, Gilchrist and Sim (2007) allow the logarithms of the variables describing demand and productivity conditions, $X_{d,t}$ and $X_{f,t}$, to depend linearly on real activity in each market and the exchange rate as $\log(X_{j,t}) = \alpha_i + \zeta_j \log(y_{j,t}) + \lambda_j \log(e_t)$. In this case, the expression for the exchange rate in firm sales $s_{j,t}$ becomes modified as $e^{1^{j=f}-(1-\nu)\psi_j+\lambda_j)/\Gamma_j}, j = f, d$.

$b_f - (1-\nu)\psi_f]/\Gamma_f$ instead of $b_f = 1$.[37]

Of the remaining parameters, the share of sanctioned intermediate inputs s^* is determined as follows. We use the OECD Input-Output tables to calculate the share of intermediate inputs that Russia imported from countries that imposed sanctions on it in 2014-2015 to its total intermediate imports in the pre- and post-sanctions periods. Between 2005-2013, the total value of intermediate inputs imported from sanctioning countries relative to the total value of intermediate inputs imported from all countries is 64.47%. However, between 2014 2015, this ratio falls to 58.30% on average, signifying the loss of intermediate inputs due to sanctions for Russian firms. Based on these results, we set the share of sanctioned inputs s^* according to the percentage decline in imported inputs from sanctioning countries from the period 2005-2013 to 2014-2015, yielding $64.47 - 58.30/64.47 = 9.57$. If perceptions of country risk also caused non-sanctioning countries to reduce their trade with Russia, the import of intermediate inputs by Russian firms might have fallen further. Hence, we set the share of sanctioned inputs as $s^* = 0.10$. The quarterly discount rate is chosen as 5%, which implies a discount factor of $\beta = 0.952$. The quarterly depreciation rate of capital is chosen as 2.5%. Bloom et al. (2007) assume a annualized depreciation rate of 10% while Lopez-Martin (2022) assumes a value of 6.9%. In our framework, irreversibility and expandability are two ways that the firm's investment decisions diverge from a frictionless model of investment. To provide sufficient deviation from the frictionless capital stock model, we normalize the price of new capital capital goods as unity as in Gilchrist and Sim (2007) and assume that the firm suffers a discount of 50% from this price if it tries to sell off capital.[38]

5.4 Simulations

We showed in Section 5.3 that the joint behavior of the variables $\tilde{X}_{j,t}, j = d, f$ determine the firm's short-run profitability. Hence, we begin by considering the issue of modelling the variables summarizing exogenous profitability conditions for the firm arising from demand, productivity, or exchange rate movements. As we discussed above, we use the logarithms of aggregate TFP A_t, mea-

[37] Notice that $b_f = 1 + \lambda_f$, with λ_f defined implicitly to be less than zero, consistent with the evidence in Gilchrist and Sim (2007).

[38] Bloom et al. (2007) consider two types of capital, and assumed that type 1 capital is more costly to adjust than type 2 capital. Thus, the resale loss of type 1 capital to be 50% while the resale loss for type 2 is assumed to be 20%. Lopez-Martin (2022) assumes a more modest degree of irreversibility by setting the resale price of capital to be 90% of its purchase price.

sures of domestic and foreign demand $\alpha_{d,t}$ and $\alpha_{f,t}$, real wages for labor and intermediate goods, $w_{n,t}$ and $w_{m,t}$, the price of oil for oil inputs, p_{ot},and the real exchange rate e_t together with the sanctions index s^* when defining the logarithms of the variables $\tilde{X}_{d,t}$ and $\tilde{X}_{f,t}$. The real exchange rate e_t affects $\tilde{X}_{d,t}$ by determining the cost of imported intermediate inputs and $\tilde{X}_{f,t}$ through both the value of sales in foreign markets together with the cost of imported inputs. Our approach is similar to Bloom et al. (2007), who model the demand conditions variable as a composite of a unit-level and a firm-level component in their analysis of investment decisions by UK publicly-traded firms with multiple plants. They further assume that the unit-level demand (or productivity) conditions as well as the firm-level demand processes evolve over time as an augmented geometric random walks with stochastic volatility. In our analysis, we model the joint dynamic behavior for the elements of $X_t = (\tilde{X}_{d,t}, \tilde{X}_{f,t})$ in terms of a bivariate Markov switching model, as these variables describe the common conditions affecting domestic and foreign sales for firms in the Russian economy.

Figure 3: Profitability Conditions for the Firm

(a) $\tilde{X}_{d,t}$ (b) $\tilde{X}_{f,t}$: $b_f = 0.2$

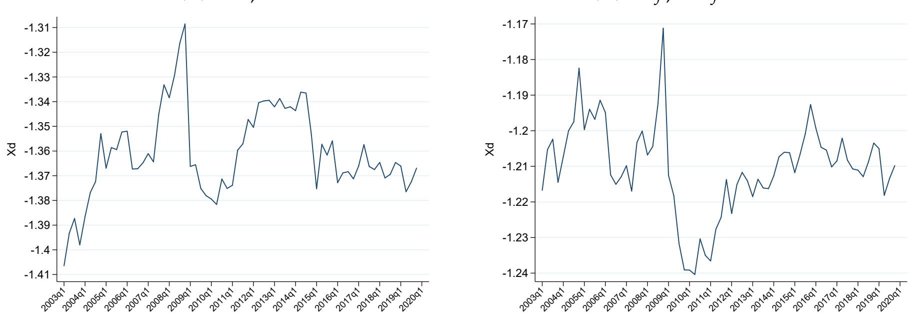


Figure 3 shows the evolution of the composite variables $\tilde{X}_{d,t}$ and $\tilde{X}_{f,t}$ over the period 2003:I-2019:IV.[39] Part (a) shows the behavior of $\tilde{X}_{d,t}$ while part (b) considers the behavior of $\tilde{X}_{f,t}$ for $b_f = 0.2$, respectively. we observe from these figures that the behavior of the underlying determinants of $\tilde{X}_{d,t}$ and $\tilde{X}_{f,t}$ interact to determine the behavior of the composite series. While both series display large declines beginning in 2009:I reflecting the effect of the Global Financial Crisis of 2008-2009, $\tilde{X}_{f,t}$ is higher overall throughout the sample period in part (b) because it reflects the positive effects of the real exchange rate, which determines the impact of sales in foreign markets. Furthermore, $\tilde{X}_{f,t}$

[39] We use a longer sample period that reflects the availability of data on the aggregate series to construct the variables $\tilde{X}_{j,t}, j = d, f$ and to uncover their time series properties compared to our sample of Russian non-financial firms.

tends to fall less after the imposition of sanctions in 2014, partly because the nominal exchange rate devaluation is associated with an increase in the terms of trade for Russian goods. Indeed, part (b) of this figure shows that $\tilde{X}_{f,t}$ shows a sustained rise after 2014 despite the effect of sanctions. This occurs because the decline in the oil price interacts with the increase in the real exchange rate over this period, thus improving the prospects for firms operating in the foreign sector.

Table 9: ALTERNATIVE SCENARIOS

	Summary Statistics				
	$E(I/K)$	$CV(I/K)$	$\frac{E(I\|I>0)}{E(I)}$	Prop$(I \leq 0)$	χ_{11}
I) $b_f = 0.2, s^* = 0.1$					
(a) $\beta = 0.952$	0.095	5.11	3.42	6.5	0.592
(b) $\beta = 0.909$	0.082	5.31	3.05	4.7	0.584
II.) $b_f = 0.15, s* = 0.15$					
(a) $\beta = 0.952$	0.051	5.76	2.25	2.0	0.643
(b) $\beta = 0.909$	0.040	5.56	1.76	1.1	0.650
III.) $b_f = 0.15, s* = 0.15$ and oil price cap = 50$					
(a) $\beta = 0.9502$	0.099	5.02	3.80	6.0	0.653
(b) $\beta = 0.909$	0.079	5.35	3.22	4.1	0.661

We consider several scenarios regarding fundamentals for the Russian economy in response to the Russia's annexation of Crimea in 2014 as well as its subsequent invasion of Ukraine in 2022. Table 9 presents simulations from the model under alternative assumptions about the Markov switching model characterizing the exogenous profitability conditions for the firm described in Table A.1.[40] In this table, we report the results for the case when the simulations start from a value of $k_0 = 50$ and update the capital stock optimally along any simulation path for each t. The statistics $E(I/K)$, $E(I|I > 0)$ and the proportion of $I > 0$ are mean values across 500 simulations and 400 periods (excluding the burn-in sample of 200 periods), averaged across 50 simulated regimes.[41] The ratio

[40] For a further description of the simulation process, see Section A.3 of the Appendix.

[41] We do not report the simulated values of $E(I)$ or $E(I|I > 0)$ because a subset of the variables constituting $\tilde{X}_{j,t}, j = d, f$ are defined in their actual units while others are measured as indices.

$E(I|I > 0)/E(I)$ is just the ratio of the mean values across all simulations and all time periods, averaged over the simulated regimes. The value for the coefficient of variation ($CV(I/K)$) is calculated using all the observations on the investment-capital stock ratio from 500 simulations and 400 time periods jointly (excluding the burn-in sample of 200 periods), averaged across 50 simulated regimes. Finally, in the last column of Table 9, we report the fraction of cases when $\chi_{11} = 1$ across the 50 simulations for the regime.

The baseline scenario reported in Table 9 assumes a value of $b_f = 0.2$ and $s^* = 0.1$. The baseline scenario features an average investment-capital stock ratio of 9.5% across all simulations and periods and a coefficient of variation of 5.11, indicating significant variation in the level of investment expenditures.[42] We also find evidence for the existence of capital sales as measured by the average level of investment expenditures, conditional on investing, as being nearly three and a half times greater relative to the simple mean of investment expenditures and calculate the proportion of cases with capital sales across all time periods and all simulations as 6.5% .

Next, we consider a scenario where we increase the sanctioned trade index s^* to 15% and reduce the coefficient of the exchange rate on foreign sales to $b_f = 0.15$. Both assumptions could imply a tightening of sanctions, as observed during 2022-2023, with Russian firms facing tighter restrictions on imports of intermediate goods such as electro-magnetic chips and greater difficulty in penetrating foreign markets despite a more competitive exchange rate.[43] Compared to the baseline scenario of $s = 0.1, b_f = 0.2$, we observe that that increasing s^* from 10% to 15% while simultaneously reducing b_f to from 0.1 to 0.15 causes the average investment-capital stock ratio, $E(I/K)$, to fall by nearly 50% and the coefficient of variation to increase by 13%. Interestingly, we observe from Figure 2 that the investment-capital stock ratio is around 9% in 2013 , after which it started to falls to 4% by 2015. Likewise, the ratio of the average value of investment, conditional on investing, $E(I|I > 0)$ relative

[42]We can also calculate a second measure of the investment-capital stock ratio which smooths some of the excess variation in investment and the capital stock across all the simulations and dates. For this purpose, we first calculate the average value of investment expenditures and the existing capital stock across 500 simulations for each t denoted by I_t^m and K_t^m and find the average of the quantity $I_t'^m/K_t'^m$ across all time periods t' that begin after the burn-in sample and across all regimes for each t'. For each reported scenario, the time average of the simulated means of the I/K ratio is estimated to be close to the steady state of the investment-capital stock ratio of $\delta = 0.025$.

[43]Repeating the calculations for the changes in the share of imported intermediate and capital inputs from sanctioning countries relative to the imported intermediate and capital inputs from all countries, we find that the percentage difference between the period 2003-2013 and 20-2021 is 18%. If we consider the ratio of imported intermediate and capital inputs from sanctioning countries relative to the inputs of imported intermediate, capital and consumption goods, this difference is 16%, which is close to our assumed value of 15%.

to $E(I)$, is lower compared to scenario I. These results reflect the fact that under scenario II, the mean values of both $\tilde{X}_{d,t}$ and $\tilde{X}_{f,t}$ decline compared to scenario I. While the variability of these series also increase in the regime with more favorable fundamentals, they tend to fall in the regime with worse fundamentals. Hence, the firm tends to invest less in an environment with a greater proportion of sanctioned inputs and less realized income from sales in foreign markets, as average profitability tends to fall in such an environment. Finally, the proportion of capital sales or disinvestment across all simulations and time periods (excluding the burn-in period) is lower under scenario II compared to scenario I.

On December 2022, the G7 countries agreed on a price cap of oil at $60 per barrel. Wachtmeister et al. (2023) estimate that the losses to Russia from every $10 decrease in the price of crude oil below the world price of oil are on the order $110 million per day, or around 2.3% of Russian GDP. Furthermore, only a third are compensated by an increase in Russian consumer surplus, as some oil is diverted to the domestic market. As our earlier analysis shows, the Urals price of crude oil collapsed to around $30 per barrel by the beginning of 2016 before recovering to $60 per barrel by the end of 2017. Wachtmeister et al. (2023) seek to determine the optimal price cap under several different configurations of world gains and Russian losses and conclude that a price cap of $50 is most likely optimal for world consumers.[44] Hence, in what follows, we consider an oil price cap of $50 as of 2017:I that continues until the end of our sample. In our analysis, we need to model the behavior of the domestic demand shock under such as an oil cap scenario. Gurvich and Prilepskiy (2015) argue that the decline in GDP and other indicators for the Russian economy could be attributed more to the decline in oil prices than sanctions during 2015-2017. They show that financial sanctions imposed on Russian individuals and entities had the effect of reducing real GDP by 2.4% in 2017 relative to its pre-crisis level. By contrast, the decline in the oil price led to GDP losses of 8.5% between 2014-2017. Using these results as a benchmark, we assume that GDP growth is 0.4% lower from 2017:I to the end of our sample as a way of capturing the demand effects of an oil price cap.[45]

The results in Table 9 show that the decline in the oil price interacts with the worsening of domestic demand conditions. On the one hand, the investment-capital stock ratio is slightly higher

[44] However, under an objective of combining world consumer surplus and Russian producer losses, a price of $30 inflicts greater Russian losses than the decline in importer gains.

[45] Notice that this is a more conservative annual estimate of the GDP losses compared to the period between 2014-2017 but it is also more in line with an oil price cap of $50 relative to the lower oil prices in the earlier period.

than under the baseline scenario I while the coefficient of variation in investment is slightly lower compared to scenario I. Table A.1 that the regime-switching means for both $\tilde{X}_{d,t}$ and $\tilde{X}_{f,t}$ are higher under scenario III than under II, as the price cap leads to lower prices for domestic producers, while the regime-switching variances are also higher. As Wachtmeister et al. (2023) argue, tightening of sanctions may also be accompanied by countervailing policy measures. Hence, the scenario in part III of Table 9 may be implicitly reflecting such measures which prevent domestic demand from falling more. Although we do not report the values of average investment and the capital stock, it is important to note that the average level of investment $E(I)$ and the average of the capital stock $E(K)$ calculated across all simulations, time periods, and regimes do fall in response to this policy experiment. Hence, the oil price cap does have the effect of reducing investment activity and the economy's productive capital stock, although these declines are in the same proportion to keep the average investment-capital stock ratio $E(I/K)$ essentially constant or slightly higher compared to scenario I.

It is also possible to examine how these results change if future profits for the firm are discounted at a higher rate. We already noted that overnight interest rates were hiked from 8.5% to 17% in December, 2014 by the Central Bank of the Russian Federation to halt the ruble depreciation. We assume that this event would also have the effect of increasing the discount rate used by firms to discount future profits. To capture this, we assume that the discount factor β was modified as $\beta' = \beta/(1+0.05) = 0.907$. Table 9 shows that the average values of the investment-capital stock ratio, $E(I/K)$ fall, and the coefficient of variations, $CV(I/K)$¡ increase under scenarios I-III with a higher discount rate for future profits. In particular, the investment-capital stock ratio, $E(I/K)$, falls by nearly 14% under scenario I and by 22% and 20% under scenarios II and III while the coefficient of variation increases under scenarios I and III but falls under scenario II.

In our analysis up to this point, we displayed the investment response in an environment where the regime in effect switches randomly in each period. It is also possible to observe the investment response of firms under known regimes or regime switches (Altug et al., 2007). Specifically, we could consider how the investment response of firms varies if the firm is in the regime with more favorable fundamentals for a certain period and then switches to another regime at some known date. It turns out that the average level of investment $E(I)$ always falls when the firm finds itself in the regime with less favorable fundamentals. However, since the firm knows for sure which regime it is residing in, it has the ability to change its capital stock in response to the new fundamentals. As a result, the investment-capital stock may or may not fall, depending on the relative size of these changes. In results that are available upon request, we find that transiting from the "good" regime to the "bad" regime after 200 periods (excluding the burn-in sample) leads to slight declines in $E(I/K)$ under scenarios I and III but a slight increase in this quantity under scenario II. On the other hand, if the firm knows that it is in the "bad" regime forever, then the value of the investment-capital stock ratio decreases under scenario II, which has the worst fundamentals among the three different scenarios, but it tends to increase slightly under scenarios I and III. These results show how fundamentals interact with regime shifts determining their distributions to produce results regarding the investment response of the economy under alternative scenarios.

6 Conclusion

In this paper, we examine the impact of sanctions on the behaviour of Russian non-financial firms using a rich panel data set that is constructed using the Ruslana historical product compiled by BvD. To our knowledge, no comprehensive analysis exists that attempts to trace through the effects of sanctions against Russia imposed in 2014 on investment behavior using micro level and sectoral data. Our analysis allows for the confounding effects of ruble depreciation together with oil price changes and incorporates the balance sheet effects of exchange rate changes on firm behavior.

Our view is that any policy conclusions that ignore the dynamic interrelationship between geopolitical factors such as sanctions together with the fluctuations in oil prices and other macroeconomic factors will prove insufficient for understanding the future trajectory of a key global economic and political player such as Russia. While our analysis pertains to the impact of sanctions imposed after 2014, our structural analysis provides insights regarding issues such as an oil price cap. Our analysis thus suggests further directions for potential study using sectoral and firm-level variation in investment rates, productivity and other macroeconomic indicators.

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A Numerical solution of the model

This section presents the different results used to generate numerical solution and simulation of the model. We first derive an analytical representation for the short-run profit function following the approach in Altug et al. (2007) and Gilchrist and Sim (2007). Second, we estimate Markov switching processes for the composite variables characterizing the firm's profitability. Third, we describe the numerical solution and simulation approach used in the paper.

A.1 Deriving the short-run profit function

In this section, we derive the profit function for the case where we allow for the competitiveness channel of the exchange rate, the sanctioned trade channel and the effect of oil prices jointly.

Consider the static problem for the firm that involves maximizing profits by choice of the inputs $n_{j,t}, m_{j,t}, j = f, d$. Substituting for the (inverse) demand functions $p_{j,t}, j = f, d$, the problem becomes

$$
\begin{aligned}
\Pi(K_t, h_t) \quad = \quad & \max_{l_{j,t}, m_{j,t}, o_{j,t}, j=f,d} \Big\{ e_t \alpha_{f,t}^{-\frac{1}{\epsilon^f}} y_{f,t}^{\frac{1}{\epsilon^f}} y_{f,t} + \alpha_{d,t}^{-\frac{1}{\epsilon_d}} y_{d,t}^{\frac{1}{\epsilon_d}} y_{d,t} - w_{n,t}(n_{d,t} + n_{f,t}) \\
& - \frac{w_{m,t} e_t}{1 - s^*}(m_{d,t} + m_{f,t}) - p_{o,t}(o_{d,t} + o_{f,t}) \Big\} \\
\text{s.t. } \; & y_{d,t} + y_{f,t} = A_t K_t^{\eta \nu_1} \left[n_{d,t}^{\nu_1(1-\eta)} m_{d,t}^{\nu_2} o_{d,t}^{1-\nu_1-\nu_2} + n_{f,t}^{\nu_1(1-\eta)} m_{f,t}^{\nu_2} o_{f,t}^{1-\nu_1-\nu_2} \right].
\end{aligned}
$$

Let $\psi_j = (1 + \varepsilon_j)/\varepsilon_j$. Notice that $0 < \psi_j < 1$ for $\varepsilon_j < -1$. Let $1(j = f)$ denote an indicator function which takes on a value of 1 if $j = f$ and 0 otherwise. The first-order conditions with respect to $n_{j,t}, m_{j,t}, o_{j,t}, j = f, d$ are

$$
\begin{aligned}
\psi_j(1-\eta)\nu_1 e_t^{1(j=f)} \alpha_{j,t}^{-\frac{1}{\varepsilon_j}} y_{j,t}^{\frac{1}{\varepsilon_j}} A_t K_t^{\nu_1 \eta} m_{j,t}^{\nu_2} o_{j,t}^{1-\nu_1-\nu_2} n_{j,t}^{\nu_1(1-\eta)-1} - w_{n,t} &= 0, && \text{(A.1)} \\
\psi_j \nu_2 e_t^{1(j=f)} \alpha_{j,t}^{-\frac{1}{\varepsilon_j}} y_{j,t}^{\frac{1}{\varepsilon_j}} A_t K_t^{\nu_1 \eta} n_{j,t}^{\nu_1(1-\eta)} m_{j,t}^{\nu_2 - 1} o_{j,t}^{1-\nu_1-\nu_2} - \frac{e_t w_{m,t}}{1-s} &= 0, && \text{(A.2)} \\
\psi_j(1-\nu_1-\nu_2) e_t^{1(j=f)} \alpha_{j,t}^{-\frac{1}{\varepsilon_j}} y_{j,t}^{\frac{1}{\varepsilon_j}} A_t K_t^{\nu_1 \eta} n_{j,t}^{\nu_1(1-\eta)} m_{j,t}^{\nu_2} o_{j,t}^{-\nu_1-\nu_2} - p_{o,t} &= 0, && \text{(A.3)}
\end{aligned}
$$

for $j = f, d$. Let the sales of the firm in market j at time t be given by $S_{j,t} = e_t^{1(j=f)} \alpha_{j,t}^{1-\psi_j} y_{j,t}^{\psi_j}$. Now we can write the input demand functions as

$$\begin{aligned} n_{j,t} &= (1-\eta)\nu_1\psi_j \frac{S_{j,t}}{w_{n,t}}, && \text{(A.4)} \\ m_{j,t} &= \nu_2\psi_j(1-s^*)\frac{S_{j,t}}{e_t w_{m,t}} && \text{(A.5)} \\ o_{j,t} &= (1-\nu_1-\nu_2)\psi_j \frac{S_{j,t}}{p_{o,t}}, \quad j=f,d. && \text{(A.6)} \end{aligned}$$

Proceeding as before yields

$$\begin{aligned} \Pi(K_t,h_t) &= \sum_{j=f,d} e_t^{1(j=f)-\nu_2\psi_j}\alpha_{j,t}^{1-\psi_j} y_{j,t}^{\psi_j} - w_{n,t}(n_{d,t}+n_{f,t}) - \frac{w_{m,t}e_t}{1-s}(m_{d,t}+m_{f,t}) - p_{o,t}(o_{d,t}+o_{f,t}) \\ &= \sum_{j=f,d}\left(S_{j,t} - w_{n,t}(1-\eta)\nu_1\psi_j\frac{S_{j,t}}{w_{n,t}} - \frac{e_t w_{m,t}}{1-s^*}(1-s^*)\nu_2\psi_j\frac{S_{j,t}}{e_t w_{m,t}} - p_{o,t}(1-\nu_1-\nu_2)\psi_j\frac{S_{j,t}}{p_{o,t}}\right) \\ &= \sum_{j=f,d}\Gamma_j S_{j,t} \end{aligned}$$

where $\Gamma_j = 1-(1-\eta\nu_1)\psi_j$. Under perfect competition, $\psi_j = 1$ and $\Gamma = \eta\nu_1$, which is the capital share in the production function. If there are no intermediate or oil inputs, $\nu_1 = 1$ and $\Gamma_j = 1 - \psi_j(1-\eta)$. Substituting the input demands into the sales function yields an expression for sales as

$$\begin{aligned} S_{j,t} &= e_t^{1(j=f)}\alpha_{j,t}^{1-\psi_j}y_{j,t}^{\psi_j} = e_t^{1(j=f)}\alpha_{j,t}^{1-\psi_j}A_t^{\psi_j}K_t^{\psi_j\nu_1\eta}n_{j,t}^{\nu_1(1-\eta)\psi_j}m_{j,t}^{\nu_2\psi_j}o_{j,t}^{(1-\nu_1-\nu_2)\psi_j} \\ &= e_t^{1(j=f)}\alpha_{j,t}^{1-\psi_j}A_t^{\psi_j}K_t^{\psi_j\nu_1\eta}\left((1-\eta)\nu_1\psi_j\frac{S_{j,t}}{w_{n,t}}\right)^{\nu_1(1-\eta)\psi_j}\left(\nu_2\psi_j(1-s^*)\frac{S_{j,t}}{e_t w_{m,t}}\right)^{\nu_2\psi_j} \times \\ &\qquad \left((1-\nu_1-\nu_2)\psi_j\frac{S_{j,t}}{p_{o,t}}\right)^{(1-\nu_1-\nu_2)\psi_j}. \end{aligned}$$

Then sales may be written as

$$S_{j,t} = e_t^{(1(j=f)-\nu_2\psi_j)/\Gamma_j}\Psi_j\Xi_{j,t}^{1/\Gamma_j}K_t^{\nu_1\eta\psi_j/\Gamma_j},$$

where

$$X_{j,t} = \left[\frac{A_t^{\psi_j}\alpha_{j,t}^{(1-\psi_j)}(1-s^*)^{\nu_2\psi_j}}{w_{n,t}^{\nu_1(1-\eta)\psi_j}w_{m,t}^{\nu_2\psi_j}p_{o,t}^{(1-\nu_1-\nu_2)\psi_j}}\right]$$

and

$$\Psi_j = \left[((1-\eta)\nu_1\psi_j)^{\nu_1(1-\eta)\psi_j} (\nu_2\psi_j)^{\nu_2\psi_j} ((1-\nu_1-\nu_2)\psi_j)^{(1-\nu_1-\nu_2)\psi_j} \right]^{1/\Gamma_j}.$$

A.2 Estimating bivariate Markov switching models for exogenous processes

In this section, we derive bivariate Markov switching processes for the logarithms of the elements of X_t. We consider directly the case with oil inputs, as our firm-level estimation refers to this case. We consider bivariate Markov switching process based on the behavior of an unobserved random variable s_t that takes on values of 0 and 1 and that allows for different conditional means and variances in each regime. Thus, our specification involves estimating the system

$$\begin{bmatrix} \log(\tilde{X}_{d,t}) \\ \log(\tilde{X}_{f,t}) \end{bmatrix} = \begin{bmatrix} \mu_{d,t} \\ \mu_{f,t} \end{bmatrix} + \begin{bmatrix} \rho_{d,d} & \rho_{d,f} \\ \rho_{f,d} & \rho_{f,f} \end{bmatrix} \begin{bmatrix} \log(\tilde{X}_{d,t-1}) \\ \log(\tilde{X}_{f,t-1}) \end{bmatrix} + \begin{bmatrix} \epsilon_{d,t} \\ \epsilon_{f,t} \end{bmatrix},$$

where

$$Var(\epsilon_t \epsilon_t') = \begin{bmatrix} \sigma_{d,d}(s_t) & \sigma_{f,d}(s_t) \\ \sigma_{f,d}(s_t) & \sigma_{f,f}(s_t) \end{bmatrix}$$

with $\epsilon_t = (\epsilon_{d,t} \ \epsilon_{f,t})'$. However, following Bengoechea et al. (2006), we consider bivariate models with conditionally correlated series where the unobserved state nevertheless follows a first-order Markov process with the same transition probabilities characterizing the evolution of the common state denoted by $Pr(s_{t+1} = j | s_t = i) = p_{i,j}, \ \ i,j = 0,1$ and $\sum_{j=0}^{1} p_{i,j} = 1$.

Notice that the exogenous series in our model consist of $(A_t, \alpha_{d,t}, \alpha_{f,t}, w_{n,t}, w_{m,t} p_{o,t}, e_t)$.[46] Lopez-Martin (2022) directly models the idiosyncratic technology shock $A_{j,t}$ to firms and the exchange rate e_t as stationary AR(1) processes. Gilchrist and Sim (2007) consider an exogenous state vector defined as $\mathbf{z} = (r_d, e, e_1, z, Z)$, where z is an idiosyncratic shock to the production function, Z is an aggregate shock which shifts the market demand, r_d is the domestic risk-free rate, and e is the real exchange rate. The lagged real exchange rate is a state variable because it helps to predict the evolution of the domestic interest rate under uncovered interest parity (UIP). In terms of the endogenous state

[46] We also measure the different series in different units, with A_t and $w_{m,t}$ being measured in terms of their index values and others such as $\alpha_{d,t}, \alpha_{f,t}, w_{n,t}, \ p_{o,t}$, and e_t in actual units. In particular, we measure $\alpha_{d,t}$ in terms of billions of rubles (base year = 2012) while we measure $\alpha_{f,t}$ in billions of US dollars.

variables, they summarize the information by the firm's net worth defined as $n \sum_{j=d,f} \Phi_j((z)k^\gamma + (1-\delta)k - \Omega(e, e_1; \omega) R_d b)$ model domestic economic activity $y_{d,t}$ so that the model's state variables are given by $k, n, \mathbf{z}$). Gilchrist and Sim (2007) initially estimate a firm sales equation as a function of the firm's capital stock, the real exchange rate and a measures of domestic and foreign activity, $y_{d,t}$ and $y_{f,t}$, defined as the HP-detrended Korean log-GDP and the index of world income obtained from the World Economic Outlook (WEO) data base obtained from the IMF, respectively. To characterize the sales equation in each market, they assume that the variables $X_{j,t}, j = d, f$ can be represented as log-linear function of the Hp-detrended measures of domestic and foreign real activity and the real exchange rate. In their structural estimation, they estimate univariate time series processes for the real interest rate, $r_{d,t}$, the real exchange rate, e_t, and HP-detrended domestic real activity, $y_{d,t}$. Due to the absence of variation in world over their sample period, they set foreign real activity equal to a constant.

In our analysis, we construct the variables $\tilde{X}_{j,t}, j = d, f$ from their underlying determinants. We first tested for unit roots in all the determinants of the composite variables determining domestic and foreign profitability conditions. We were unable to reject the null hypothesis of unit roots in the logarithms for any of the variables except the real exchange rate. Next, we tested for unit roots in the logarithms of $\tilde{X}_{d,t}$ and $\tilde{X}_{f,t}$ using Dickey-Fuller unit root tests. For this purpose, we parameterized the impact of the exchange rate on $\tilde{X}_{f,t}$ on $\tilde{X}_{f,t}$ by $b_f - (1-\nu)\psi_f$ with $b_f = 0.15, 0.2$ and different values of s^*. Based on these tests, we are able to reject the null hypothesis of a unit root with a p-value of 0.0153 for $\tilde{X}_{d,t}$ and 0.0465 for $\tilde{X}_{f,t}$ when $b_f = 0.2$ and $s^* = 0.1$. We were also able to reject the null hypothesis of a unit root with a p-value of 0.0210 for $\tilde{X}_{d,t}$ and 0.150 for $\tilde{X}_{f,t}$ when $b_f = 0.15$ and $s^* = 0.15$. By comparison, we fail to reject the null hypothesis of a unit for $\tilde{X}_{f,t}$ when $b_f = 0.2$ and $s^* = 0.2$ with a p-value of 0.0707. Thus, in contrast to directly assuming a stationary representation for the composite variable entering the firm's sales equation, the parameter configurations that we employ in our simulation exercise yield stationary representations for the logarithms of $\tilde{X}_{j,t}, j = d, f$, suggesting that stochastic trends that may exist in their underlying determinants are eliminated through linear combinations of the logarithms of such variables.

We considered reformulating the short-run profit function as a CRTS function in $\tilde{X}_{j,t}, j = d, f$ and K_t following the approach in Bloom (2000) and transforming the model in terms of the variables

Table A.1: Estimates of the Bivariate Markov Switching Model

	Model I: $b_f = 0.2$ and $s = 0.1$		Model II: $b_f = 0.15$ and $s = 0.15$	
	Regime 0	Regime 1	Regime 0	Regime 1
$\mu_d(s_t)$	-0.1933 (0.0802)	-0.2045 (0.0869)	-0.2786 (0.0610)	-0.2937 (0.0613)
$\mu_f(s_t)$	-0.1416 (0.0512)	-0.1480 (0.0547)	-0.2489 (0.0550)	-0.2600 (0.0553)
$\sigma_d(s_t)$	6.6408e-05	7.5231e-05	8.1899e-05	5.1459e-05
$\sigma_f(s_t)$	7.1777e-05	5.1459e-05	8.3439e-05	3.9238e-05
$\sigma_{d,f}(s_t)$	6.2644e-05	5.2052e-05	7.9026e-05	3.9789e-05
$p_{0,0}$	0.8824 (0.0895)		0.8193 (0.1147)	
$p_{1,1}$		0.9205 (0.0710)		0.9237 (0.0536)
Equation for $X_{d,t}$				
$\rho_{d,d}$	0.6952 (0.3263)		0.6545 (0.1245)	
$\rho_{d,f}$	-0.2270 (0.1014)		-0.3218 (0.1344)	
Equation for $X_{f,t}$				
$\rho_{f,d}$	-0.1435 (0.2058)		-0.2119 (0.1070)	
$\rho_{f,f}$	0.7927 (0.0897)		0.6694 (0.1214)	

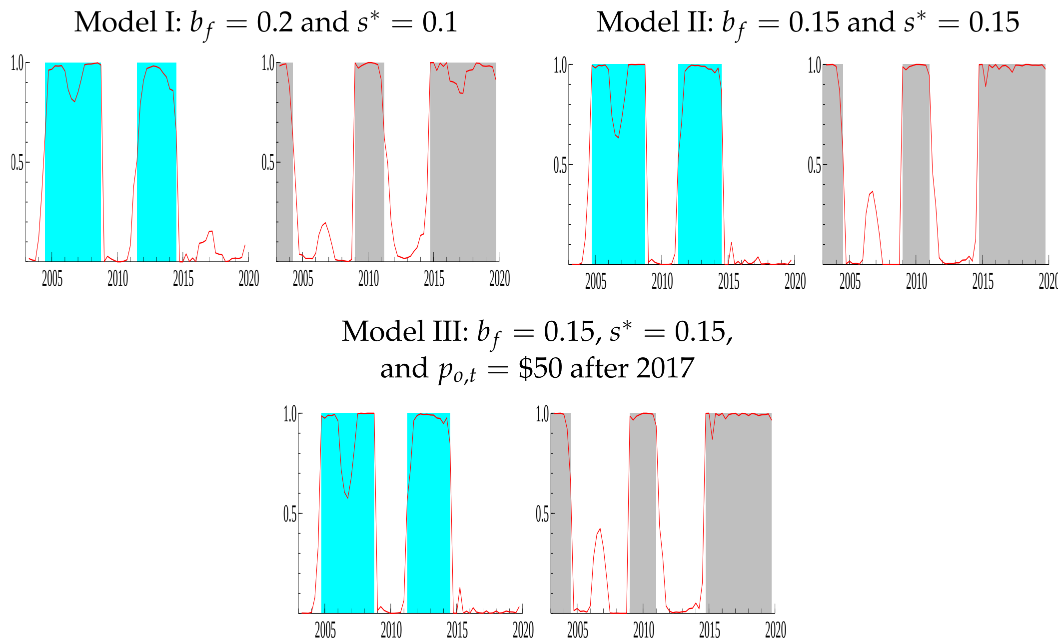
	Model III: $b_f = 0.15$, $s = 0.15$ and $p_{o,t} =$ \$50 after 2017:I			
	Regime 0	Regime 1		
$\mu_d(s_t)$	-0.2518 (0.0589)	-0.2664 (0.0590)		
$\mu_f(s_t)$	-0.2227 (0.0533)	-0.2331 (0.0534)		
$\sigma_d(s_t)$	8.1998e-05	5.3134e-05		
$\sigma_f(s_t)$	8.3740e-05	4.1632e-05		
$\sigma_{d,f}(s_t)$	7.9215e-05	4.1865e-05		
$p_{0,0}$	0.8460 (0.1249)			
$p_{1,1}$		0.7225 (0.0922)		
Equation for $X_{d,t}$				
$\rho_{d,d}$	0.6261 (0.1288)			
$\rho_{d,f}$	-0.2632 (0.1317)			
Equation for $X_{f,t}$				
$\rho_{f,d}$	-0.2366 (0.1106)			
$\rho_{f,f}$	0.7253 (0.1186)			

Standard errors in parentheses

$\tilde{X}_{f,t}/\tilde{X}_{d,t}$ and $K_t/tildeX_{d,t}$ as a way of ensuring stationary representations for different combinations of the parameters s^*, b_f, etc. However, different parameterizations of s^*, b_f failed toyield stationarity results for the ratio $\tilde{X}_{f,t}/\tilde{X}_{d,t}$. Hence, we chose to model the behavior of $\tilde{X}_{j,t}, j = d, f$ in levels and test for unit roots for each parameter specification.

Table A.1 shows the estimates of the bivariate Markov switching dynamic regression for the vector series containing the logarithms of the series describing demand, productivity and exchange rate conditions for the Russian economy using quarterly observations. This table shows that the

Figure A.1: FILTERED PROBABILITIES OF THE PROFITABILITY REGIMES



estimate of the regime-switching means for the $(\tilde{X}_{d,t}, \tilde{X}_{f,t})$ series in both regimes are negative and significantly estimated and the regime-switching means are lower in regime 0 than regime 1 for all models. However, the regime-switching variances and the covariance between $\tilde{X}_{d,t}$ and $\tilde{X}_{f,t}$ are not necessarily higher in regime 1 than regime 0 for either model. Also, the own lag of each variable enters significantly into the regime-switching regression that characterizes their own behavior but the lags of the other variable are not always estimated significantly.[47]

The Markov switching model also delivers estimates of the probabilities of remaining in the different regimes. For the first three models, the probability of remaining in each regime is similar, given by $p_{0,0} = 0.8824$ and $p_{1,1} = 0.9205$ for Model I, by $p_{0,0} = 0.8193$ and 0.9237 for Model II and by $p_{0,0} = 0.8460$ and $p_{1,1} = 0.9219$ for Model III. The different regimes implied by these estimates are further graphed in Figure A.1. These figures show that all three models essentially assign the same dates to each regime: 2004:III - 2008:IV and 2011:III - 2014:III to the regime with more favorable fundamentals and 2003:II - 2004:II, 2009:I - 2011:II and 2014:IV - 2019:IV to the regime less favorable

[47]In terms of model diagnostics, the null hypothesis of a linear model for describing the evolution of the $\tilde{X}_{j,t}, j = d, f$ series is strongly rejected with a significance level of 0 for all models. In terms of the residuals, we typically cannot reject that the residuals are serially independent but there is some evidence against normality of the residuals for the different models.

fundamentals. The estimated Markov switching model also assigns the entire period after the end of 2014 to the regime with less favorable fundamentals even though aggregate Gross Domestic Product (GDP) and Total Factor productivity (TFP) show a rebound after 2016; see 1. One reason that our baseline model may attribute longer periods for firms with worse fundamentals may be because it minimizes the role of the exchange rate.

A.3 Solving and simulating the model

We use the method of numerical dynamic programming with a discretized grid for $X_{d,t}$, $X_{f,t}$ and K_t to obtain solutions for optimal investment I_t or alternatively, next period's capital stock, K_{t+1} in the first version of our model. We choose the capital stock grid as an equi-spaced grid of 100 points that is defined on the interval $[(1-dev)K_s,(1+dev)K_s]$. Here K_s is the deterministic steady state capital stock evaluated under the unconditional means for $\tilde{X}_{j,t}, j=d,f$ for the regime with the more favorable fundamentals and $dev=0.99$. The steady state capital stock shows variation across different estimated Markov process for X_t, as firms adjust their long-run capital stock to fundamentals. However, since we are interested in the short-run effects of the changes in fundamentals, we choose the capital stock grid as an equi-spaced grid of 100 points that is defined with respect to the steady state capital stock in the baseline model with $s^*=0.1$ and $b_f=0.2$. This allows us to maintain comparability across the different sets of results. Assuming that the the regime with more favorable fundamentals is in effect, the steady state capital stock, K_s satisfies the nonlinear equation

$$(1-\beta(1-\delta)p^{hK}-\beta\nu\eta\sum_{j=d,f}e_t^{(1|j=f)}\Phi_j\psi_j\exp(\mu_j/(1-\rho_j)^{1/\Gamma_j}K_s^{\nu\eta\psi_j/\Gamma_j-1}=0,$$

which we are able to solve with a nonlinear equation solver.

We use the method in Tauchen (1986) to generate a discretized grid for $X_{d,t}$ and $X_{f,t}$ using the Markov switching estimates of their regime-dependent means and variances. As Table A.1 shows, only the own lagged values of $\tilde{X}_{j,t}, j=d,f$ are typically significantly estimated in the regime-switching equations for these variables. Hence, we model $\tilde{X}_{j,t}, j=d,f$ in terms of AR(1) processes with regime-switching means and standard deviations with their own lags only. We consider 25 points in the discrete grid for the exogenous shocks.[48]

The simulations proceed as follows. For each realization of the regime, we provide 500 simulations of the shocks $\tilde{X}_{d,t}$ and $\tilde{X}_{f,t}$ for 600 periods, with a burn-in sample of 200, and 50 simulations over the regime. Thus, the algorithm is as follows.

Step 1 Consecutively simulate the realization of the regime for each $t = 1,400$ by matching the estimated regime shift probabilities $\chi_{j,j}$ with the realizations drawn from a uniform distribution on $[0,1]$

Step 2 Given the regime $s_t = 0,1$ for each t, simulate 500 realizations of $\tilde{X}_{d,t}$ and $\tilde{X}_{f,t}$ using the probabilities from the estimated discrete Markov chain characterizing their transitions for the regime at each date.

Step 3 Evaluate current investment I_t and next period's capital stock K_{t+1} at the simulated values of the exogenous series $\tilde{X}_{d,t}$ and $\tilde{X}_{f,t}$ and current period capital stock K_t using the decision rule for the regime that is in effect. Using these observations, form the investment-capital stock ratio as I_t/K_t.

Step 4 Repeat this process 50 times by returning to Step 1 and drawing a new realization of the regime.

B Data

In our analysis, we obtain firm-level data through the Orbis global commercial data set compiled by BvD—a Moody's Analytics company. In this paper, we use one of the historical products compiled by BvD, known as "Ruslana." The Ruslana historical product provides financial statements of firms operating in Russia, Ukraine and Kazakhstan. To create unbalanced panels of firms operating in the non-financial sectors of these three countries, we follow the instructions outlined in Online Appendix A.5 of Kalemli-Ozcan et al. (forthcoming). This involves downloading data for Russian firms, Ukrainian firms, and Kazakh firms from this product, and subsequently applying the data cleaning steps, as described in the following section.

[48] Terry and Knotek (2011) extend Tauchen's method to Markov chain approximation of vector auto-regression frameworks but this requires numerical integration, which is beyond the scope of this study.

B.1 Data Cleaning Steps

Our data cleaning process comprises four steps, primarily following the methods of Díez et al. (2021); Gopinath et al. (2017); Kalemli-Ozcan et al. (forthcoming). First, we clean the raw data by eliminating basic reporting mistakes. Second, we conduct quality checks to ensure the internal consistency of balance sheet information. These initial quality checks are fundamental for any firm-level analysis. Third, we implement additional quality checks specific to this paper. Finally, in the fourth step, we perform the necessary final steps to construct the unbalanced sample of Russian non-financial firms used in our empirical analysis.

Step 1: Eliminating Basic Reporting Mistakes

1. We drop firms if any sub-categories of total assets, total liabilities, shareholders' funds, sales, and operating revenue is negative in any year.

2. We drop firms if they report total assets, the sum of shareholder funds' and liabilities, and shareholders' capital as zero in any year.

3. We drop firms if employment is either zero or negative.

4. We drop firms if employment is bigger than that reported by Walmart Inc.[49]

5. We drop firms if any sub-categories of total assets, total liabilities and shareholders' funds is missing in all years they report data to BvD.

Step 2: Ensuring the Internal Consistency of Balance Sheet Information

BvD reports total assets, total liabilities, shareholders' funds together with their respective sub-categories. We check the internal consistency of the balance sheet data by comparing the sum of the sub-categories belonging to total assets, total liabilities, shareholders' funds to their respective aggregate reported by BvD. To do so, we construct the following ratios:

[49] Walmart Inc. is an American multinational retail company that is the largest in terms of employment.

1. The sum of tangible fixed assets, intangible fixed assets, and other fixed assets as a ratio of total fixed assets.

2. The sum of stocks, debtors, and other current assets as a ratio of total current assets.

3. The sum of fixed assets and current assets as a ratio of total assets.

4. The sum of capital and other shareholders' funds as a ratio of total shareholders' funds

5. The sum of long-term debt and other non-current liabilities as a ratio of total non-current liabilities.

6. The sum of loans, creditors, and other current liabilities as a ratio of total current liabilities.

7. The sum of non-current liabilities, current liabilities, and shareholder funds as a ratio of the variable that reports the sum of shareholders' funds and total liabilities.

We check the distribution of resulting ratios and exclude the outliers by dropping observations that are below the 0.1 percentile or above the 99.9 percentile of those distributions. We apply further checks with respect to the basic accounting rules stated below:

1. In the balance sheet, the sum of the book value of shareholders' funds and liabilities should be equal to the book value of total assets. Similarly, the book value of shareholders' funds should be either equal or less than the book value of total assets.

2. In the income statement (profit & loss accounts), the monetary value of profitability measures such as net income, cash flow, EBIT, EBITDA should be less than the monetary value of either operating revenue or sales.

We drop firm-year observations if they don't satisfy these accounting rules.

Step 3: Implementing Further Quality Checks

In addition, we verify the quality of the data used in our analysis by applying the below further quality checks:

1. We drop firms with incorrect information on date of incorporation. For this purpose, we define firm age in period t as t minus the date of incorporation plus 1. By construction, age should be non-negative, so we drop firms if they don't satisfy this condition.

2. In the balance sheet, listed firms report a separate financial variable, namely, "Liabilities," whereas private firms do not. In accounting, there are three ways to construct this missing variable:

   (a) Taking the difference between the sum of shareholders' funds and liabilities and shareholders' funds or equity

   (b) Taking the difference between total assets and shareholders' funds or equity

   (c) Taking the sum of current liabilities and non-current liabilities.

   For private firms that lack "Liabilities" in their balance sheets, we follow the first two ways because in case we follow the third way, we end up with more missing firm-year observations. In accounting, either way should give us the same values. Nevertheless, as a further quality check on this particular account, we compare the values constructed following the first two ways with those constructed following the third way. We drop firm-year observations where the values are different from each other by 1,500 PPP dollars.

Step 4: Final Cleaning Steps

1. BvD reports financial statements with respect to different consolidation codes i.e. C1, C2, U1 and U2.[50] To avoid double accounting in our analysis, we keep only U2 and U1 accounts.

2. Following Crimea annexation of Russia in 2014, the data provider, Moody's started to mark Crimea companies as Russian with the "new" ID Number. We detect such cases in the data and exclude them from the Russian sample.

3. We drop firms with missing information on industry activity.

[50]C1: account of a company- headquarter of a group, aggregating all companies belonging to the group (affiliates, subsidiaries, etc.), where the company headquarter has no unconsolidated account, C2: account of a company-headquarter of a group, aggregating all companies belonging to the group (affiliates, subsidiaries, etc.) where the company headquarter also presents an unconsolidated account, U1: account of a company with no consolidated account, and U2: account of a company with a consolidated account.

4. We drop firms that provide financial and insurance services as well as those operate in the sectors outside SNA production boundary. This corresponds to the exclusion of sectors K, T & U according to NACE Revision 2 Industry Classification from our analysis.

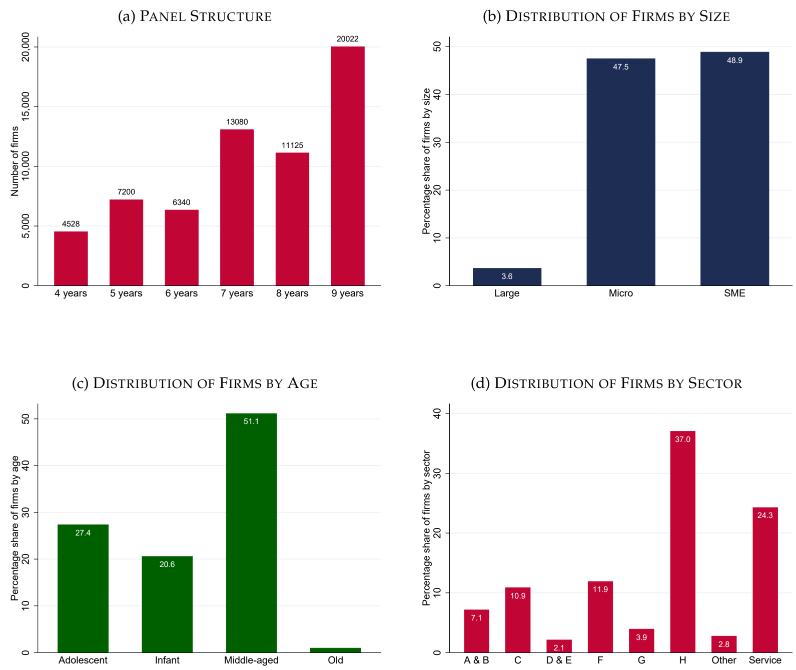
5. We exclude firms with less than three consecutive years of data

6. In the resulting sample, we retain firms that have a presence for at least three years before the sanctions regime was instituted and at least one year while the sanctions regime was in place.

B.2 Descriptive statistics

In this section we provide descriptive statistics about the unbalanced panel of Russian non-financial firms used in our analysis. Panel (a) of Figure B.2 illustrates the structure of this unbalanced panel by counting the firm-year observations that have non-missing data on all of the variables in question for 4 or more years. We observe that there are 62,295 firms that have no missing data for 4 years or more, suggesting an adequate number of firms for our analysis during the period 2004–2016.

Figure B.2: Details on the Structure of the Sample of Russian Non-financial Firms



Notes: Panel (a) illustrates the structure of the unbalanced panel used in our analysis for the period 2004-2016. It shows the number of firms in this sample that do not have missing data on all of the variables in question for 4 or more years during the period 2004–2016. Panel (b): We follow Eurostat definitions to classify firms according to their size. "Micro" firms are the ones with less than 10 employees, SMEs are firms with 10-249 employees and "Large" firms are the ones with more than 250 employees; Panel (c): "Infant" firms are less than 3 year old; "Adolescent" firms between 3-5 years, "Middle-aged" firms between 5-24; and "Old" firms greater than 25 years; Panel (d): See Table B.2 for the corresponding industry definitions of the letters representing different sectors in the bars.

Table B.2: Sectoral classification of economic activities in the Eurostat

A&B	Agriculture, forestry and fishing and Mining and quarrying
C	Manufacturing
D&E	Electricity, gas, steam and air conditioning supply and water supply; sewerage, waste management and remediation activities
F	Construction
G	Wholesale and retail trade; repair of motor vehicles and motorcycles
H	Transportation and storage
Service	Non-financial market services, which include accommodation and food services; information and communication; real estate activities; professional, scientific and technical activities; and administrative and support services activities

Notes: We follow Eurostat's broad industry definitions to determine the sectoral categories listed in this table.

Panels (b)–(d) of Figure B.2 shows the characteristics of our sample by (i) size, (ii) age and (iii) sector, respectively.[51] We observe that 3.6% of the firms in our sample are considered as "Large"

[51] We follow Eurostat's size categories to label firms in our sample. "Micro" firms are ones with the number of employ-

firms while 47.5% are "Micro" firms and 48.9% are SMEs. This suggests that micro firms and SMEs constitute a significant portion of our sample, highlighting the main departure of our study from the literature that investigates the firms' financial and real decisions. In terms of age, there is a more even distribution of firms, with over half of the firms being classified as "middle-aged (aged 5-24)" and 27.4% and 20.6% as "adolescent (aged 3-5)" and "infant (aged 0-2)", respectively, while the fraction of "old (aged >25)" firms is negligible. This says that differences in investment behavior of different ages is likely to be mitigated by the consideration of a sample that has at least half of the firms who have been in business for a sufficiently long number of years. Lastly, Panel (d) reports the distribution of firms in our sample by sector. We observe that "Services" account for 24.3% of the total number of firms. In terms of non-service sectors of the economy, "Agriculture, forestry and fishing" and "Mining and quarrying" (A&B) account for 7.1% of the firms, "Manufacturing (C)" for 10.9%, "Construction (F)" for 11.9% and "Transportation and storage (H)" for 37% of the firms, suggesting an adequate coverage of sectors of the Russian economy.

B.3 Comparing the coverage with Rosstat data

To show the Russian data used in our analysis is representative, we summarize the coverage based on the number of firms as well as gross value-added (VA) recorded in our data relative to the same item reported by the Russian statistical agency Rosstat, focusing on the period 2011–2014.[52] Rosstat conducts a sample survey to track the firms registered operating in Russia and reports the total number of firms at the end of the year as obtained from the survey.[53] Ruslana reports on firms that employ at least one employee, whereas individual enterprises constitute a significant portion of total firms reported by Rosstat.[54] The data on gross value-added reported by Rosstat are from the national accounts and represent the universe of Russian firms.[55] The operating revenue aggregates

ees less than 10, SMEs with the number of employees between 10 and 249 and "Large" firms have employees that number than greater than 250.

[52]We begin our analysis using the Russian sample in 2004, however the Russian statistical agency Rosstat reports the measure of economic activity, namely gross value-added since 2011.

[53]The number of firms reported by Rosstat are obtained from the first column of Table 8.2 of Wildnerova and Blöchliger (2020).

[54]According to the SME census conducted by the Russian SME Resource Centre (RCSME), as of January 2015, the core of the SME sector is composed of individual enterprises (i.e., 53.3% of all SMEs). For further details on the Russian SME sector, see https://rcsme.ru/index.php/en/statistics2015.

[55]Rosstat reports the breakdown of gross value-added, grouping the total economy according to 1 digit NACE Revision 2 industry classification. Since the national accounts from Rosstat lack gross value-added information for the sector "U:

we calculate using our data are conservative because we drop observations with missing, zero, or negative values for operating revenue and winsorize operating revenue at the 5% level such that its kurtosis falls below a threshold of 10.[56]

The values in the first row of Panel A in Table B.3 illustrate the firm coverage of our data constructed from the Ruslana historical product relative to Rosstat, with respect to the number of firms in the given year. Each cell corresponds to the number of firms in the total economy from our data relative to that reported by Rosstat. As noted above, because of the fact that our data doesn't have information on the individual enterprises, such a comparison based solely on the number of firms might be misleading. Despite this caveat, our data represents the firm coverage of the Russian economy reasonably well, that is, on average 30% of Russian firms is reported in our data between 2011–2014.

Table B.3: DESCRIPTIVE STATISTICS OF THE RUSLANA DATA

Panel A: Coverage in Ruslana relative to Rosstat				
Year	2011	2012	2013	2014
Number of firms	0.12	0.27	0.38	0.43
Gross VA	0.50	0.68	0.74	0.79
Panel B: Share of Firm Coverage by Size Class in 2015				
Data Source	Micro	Small	Medium	
RCSME	0.882	0.112	0.006	
Ruslana	0.838	0.156	0.006	

In the same table, the second row in Panel A suggests an alternative comparison based on a more informative measure, gross value-added. Each cell corresponds to aggregate gross value-added of the total economy from our data relative to that reported by Rosstat. The coverage in our data is continuously above 50% and averages almost 68% for gross value-added.

Panel B in Table B.3 shows the share of firm coverage accounted for by firms belonging in three size categories in 2015. The first three rows report ratios from RCSME and the next three from our data built on the Ruslana historical product. The entries in the table denote the fraction of firm

Activities of extra-territorial organisations and bodies," we exclude this sector in the calculations based on our data.

[56]The Ruslana historical product doesn't contain information on the materials used in the firm's production, thus alternatively we use the firm's operating revenue to proxy the firm's value-added.

coverage accounted for by firms belonging to each size class.[57] Our data mimics the firm-size distribution in the SME sector of Russia. For instance, the share of micro-sized, small-sized and medium sized from RCSME are 88.2%, 11.2%, and 0.6% respectively, which are very close to the percentages of micro-sized (83.8%) and small-sized (15.6%) and medium sized (0.6%) reported by our data. This provides an advantage over the studies in the literature that use the sample constructed from a single vintage that under-represents micro and small sized firms operating in the country of interest.

B.4 Variable definitions

The main variables used in the analysis are total assets, operating revenue, components of fixed assets, components of debt, employment, net income, and depreciation expense. We transform nominal financial variables to real using the GDP deflator with 2005 as the base year. The construction of these variables is described in the below.

Depreciation expense: The financial statements of Russian firms obtained from the Ruslana database lack information regarding depreciation expenses. To estimate depreciation expenses for Russian firms, we utilize Ukrainian sample from the Ruslana database that provides such information. Our approach involves employing the nearest neighbor matching procedure by which a given Russian firm is matched with its Ukrainian counterpart from the same year and industry, taking into account approximate size. Consequently, we successfully match nearly 50% of Russian firms. For those Russian firms that remain unmatched, we impute their depreciation values by calculating the mean depreciation of matched Russian firms within the same industry and with finer granularity based on company size.

The gross investment rate: We measure gross investment rate by capital expenditure scaled by beginning-of-year's book value of total assets. Capital expenditure at the end-of-year equals to book value of fixed assets minus beginning-of-year's book value of fixed assets plus end-of-year's depreciation expense.

[57] RCSME defines the size categories as follows: micro-sized firm is the one with employment less than 15 and with sales revenue less than 60 million RUR; small-sized firm is the one with 16-101 employees and with sales revenue less than 400 million RUR; medium-sized firm is the one with 101-250 employees and with sales revenue less than 1 billion RUR.

Growth opportunities: Unlike other studies, in our empirical framework, we analyze investment decisions of privately held firms that don't have the market values of balance sheet items in Orbis. For this reason, to control for the firm's growth opportunities we use the firm's sales growth, which is defined as the annual change in the firm's net real sales.[58],[59]

The firm's debt burden: We measure the firm's debt burden as its interest payments plus financial costs divided by gross operating revenue plus gross financial revenue.

The firm's profitability: This is proxied using the ratio of cash flow to total assets. We compute cash flow as net income plus depreciation expense.

The firm's size: We measure the firm's size by the logarithm of total assets.

The firm's leverage: This is measured by the ratio of the book value of total liabilities to the book value of total assets. Total liabilities are measured as the sum of long-term liabilities and short-term liabilities. Long-term liabilities consist of long-term debt such as bank loans and bonds with maturity above one year that originate in the financial system and other non-current liabilities. Short-term liabilities comprise short-term debt such as loans and bonds with maturity up to one year that originate in the financial system and accounts payable such as trade credits that originate outside the financial system and other current liabilities. We compute the firm's financial leverage as the ratio of financial debt to total assets, focusing on total debt borrowed only from financial institutions.

The ratio of foreign-currency denominated debt to total assets: This is obtained at the firm-level implementing the steps outlined in Kalemli-Ozcan et al. (2021). The Ruslana database does not provide the break down of debt and assets by currency denomination. To construct the firm-level FX debt, we use data from the Bank for International Settlements (BIS) on the country-level FX debt.[60]

[58] When using net sales, we lose a significant number of observations due to missing data on net sales, therefore we use the firm's operating revenue which is highly correlated with its net sales in a given year.

[59] Among others, net sales growth is the most appropriate measure for private firms to proxy profitable growth opportunities and commonly used in recent literature; see, for example, Kalemli-Özcan et al. (2022).

[60] There are two data sets available from the BIS for this purpose. The first data set is BIS Global Liquidity Indicators that provide data on country-level FX debt which is the sum of FX bonds and FX loans. FX bonds are debt securities issued in the US dollar, Euro and Japanese yen and issued in international markets by the residents in the non-financial sector of a given economy. FX loans are bank loans extended to the non-bank sector of a given economy both by domestic banks and by international banks denominated in the US dollar, Euro and Japanese yen. The second data set is the BIS Total Credit Database. It provides data on total loans and debt securities used for borrowing by the residents in the non-financial sector of a given economy. Since these data sets cover total loans and bonds, they provide information on loans and bonds denominated both in domestic and foreign currencies.

Using these data sets, first we calculate the country-level share of FX debt, defined as total Russia's FX debt divided by its total debt, where we divide the sum of loans and bonds in foreign currency from the first data set by the sum of total loans and bonds from the second data set. The resulting country-level share of FX debt for Russia is then multiplied by firm-level financial leverage that is calculated based on the sample of Russian non-financial firms obtained from the Ruslana database.[61,62] Also, we multiply country-level share of FX debt with firm-level leverage to obtain the alternative FX debt ratio used in our empirical analysis.

B.5 The coverage of the oil-and gas-sector

As discussed in in Section 4.5, we estimate Equation (4) using the samples of non-energy producing firms. To construct these samples, we identify the companies that pursue oil and gas related activities with respect to the NACE Revision 2 Industrial Classification. We give in the below the details on oil and gas related activities that are provided by the Eurostat:

06 Extraction of crude petroleum and natural gas: This division includes the production of crude petroleum, the mining and extraction of oil from oil shale and oil sands and the production of natural gas and recovery of hydrocarbon liquids. This division includes the activities of operating and/or developing oil and gas field properties. Such activities may include drilling, completing and equipping wells; operating separators, emulsion breakers, desalting equipment and field gathering lines for crude petroleum; and all other activities in the preparation of oil and gas up to the point of shipment from the producing property. This division excludes:

- oil and gas field services, performed on a fee or contract basis, see 09.10
- oil and gas well exploration, see 09.10
- test drilling and boring, see 09.10
- refining of petroleum products, see 19.20

[61] We prefer using firm-level financial leverage because the standard measure of firm leverage is a broader measure that contains trade credits or other forms of liabilities such as pension liabilities that are not considered in the country-level foreign currency denominated liabilities provided by the BIS database.

[62] This assumes that every firm's FX share of debt in their total debt is the same and equivalent to the country-level share of FX debt in total debt.

- geophysical, geologic and seismic surveying, see 71.12.

06.10 Extraction of crude petroleum: This division includes extraction of crude petroleum oils. This class also includes extraction of bituminous or oil shale and tar sand; production of crude petroleum from bituminous shale and sand; processes to obtain crude oils: decantation, desalting, dehydration, stabilisation etc. This division excludes:

- support activities for oil and natural gas extraction, see 09.10
- oil and gas exploration, see 09.10
- manufacture of refined petroleum products, see 19.20
- recovery of liquefied petroleum gases in the refining of petroleum, see 19.20
- operation of pipelines, see 49.50

06.20 Extraction of natural gas: This division includes production of crude gaseous hydrocarbon (natural gas); extraction of condensates; draining and separation of liquid hydrocarbon fractions; gas desulphurisation. This division also includes mining of hydrocarbon liquids, obtained through liquefaction or pyrolysis. This division excludes:

- support activities for oil and natural gas extraction, see 09.10
- oil and gas exploration, see 09.10
- recovery of liquefied petroleum gases in the refining of petroleum, see 19.20
- manufacture of industrial gases, see 20.11
- operation of pipelines, see 49.50

Therefore, we identify Russian firms that pursue oil and gas related activities, which correspond to those operating in the sectors coded with the NACE Revision 2 codes listed above, namely, 06, 09.10, 19.20, 20.11, 49.50, and 71.12; and label them as "energy firms."