DISCUSSION PAPER SERIES

DP16646
(v. 2)

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MACROECONOMICS AND GROWTH

ISSN 0265-8003

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Discussion Paper DP16646
First Published 19 October 2021
This Revision 06 November 2021

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JEL Classification: C33, D22, G31

Keywords: uncertainty, Irreversible investment, Financing constraints, Russian Federation, sanctions, oil prices, ruble devaluation, Firm-Level Data

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Acknowledgements
We thank Ko\c{c} University for providing us financial support via the Ko\c{c} University Seed Research Fund (KU-SRF) Program. This research is also supported by the TUBITAK Grant 118K268.

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The Case of Russian Firms during 2004-2016*

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November 2021

Abstract

In this study, we quantify the effects of uncertainty on investment decisions for the Russian economy. We employ an empirical specification where the dynamics of investment under uncertainty are captured by an error correction model of investment. We use a rich panel of Russian non-financial firms which is uniquely suited to studying investment in Russia over the period 2004-2016. We treat the sanctions regime instituted in 2014 against entities in Russia as a quasi-natural experiment. To control for the heterogeneous effects of the ruble devaluation and oil price decline that occurred concurrently with the sanctions regime, we exploit firm-level and sectoral variation in our micro level data set that covers both large firms and SMEs. We find significant negative effects of uncertainty on the response of investment to demand shocks due to the sanctions regime after isolating the effects of foreign exchange exposure that works through balance sheet channel of the ruble devaluation, the effects of the oil-cost dependence in production as well as of the indirect effects of trade linkages with sanctioning countries on the investment rate.

Keywords: Uncertainty, wait-and-see motive, Russian Federation, sanctions, oil price shock, ruble devaluation, firm-level data
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*We thank Koç University for providing us financial support via the Koç University Seed Research Fund (KU-SRF) Program. This research is also supported by the TUBITAK Grant 118K268.

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1 Introduction

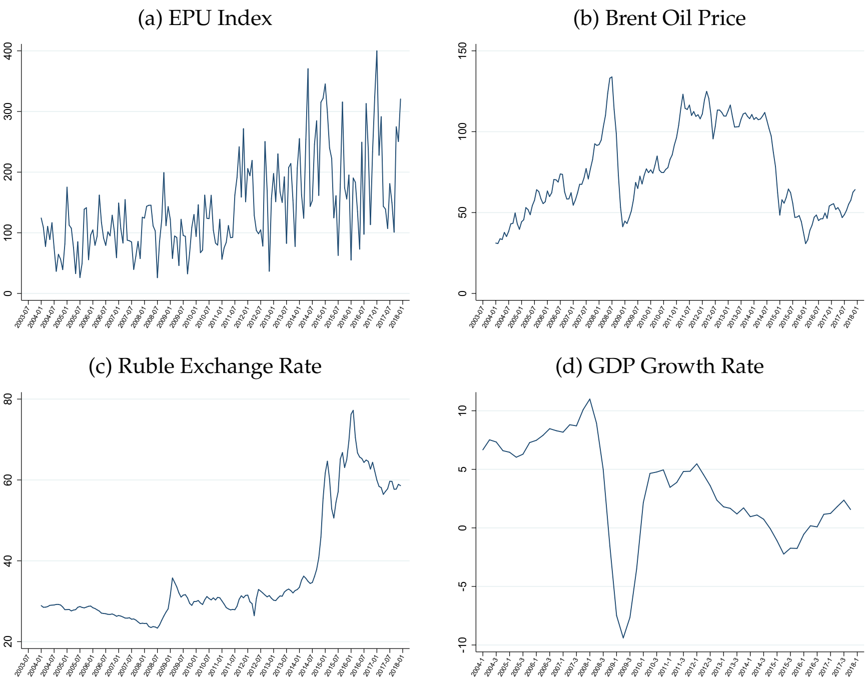
Like many emerging market economies, the Russian economy has been subject to significant sources of uncertainty and volatility since its transition from a planned economy in the 1990's. The recent Russian experience provides a unique laboratory to examine the impacts of uncertainty on investment behavior. In the Russian case, such uncertainty derives from political factors alongside macroeconomic fragility in common with many emerging market economies. As it is well known, 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.[1] In this paper, we quantify the effects of such uncertainty on investment behavior by making use of a rich panel data on Russian non-financial firms together with the implications of an error correction model of investment. This allows us to study the significant episodes of investment and disinvestment by private non-financial firms operating in Russia over the sample period of 2004-2016.

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.[2] 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. Taken together, these observations mark this period as one with

[1]These were followed by sectoral sanctions on companies representing defense industry, raw materials and financial sectors with the EU and some other countries following suit. The level of the sanctions was intensified in July 2014, 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. 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. Russia responded by announcing a set of counter-sanctions with a ban on food imports from Western countries in August 2014.

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

Figure 1: Macroeconomic indicators for Russia



SOURCES: The EPU Index is the Economic Policy Uncertainty index developed by Baker et al. (2016a) for Russia. The series on oil price, real GDP growth rate and ruble exchange rate are obtained from FRED, Federal Reserve Bank of St. Louis.

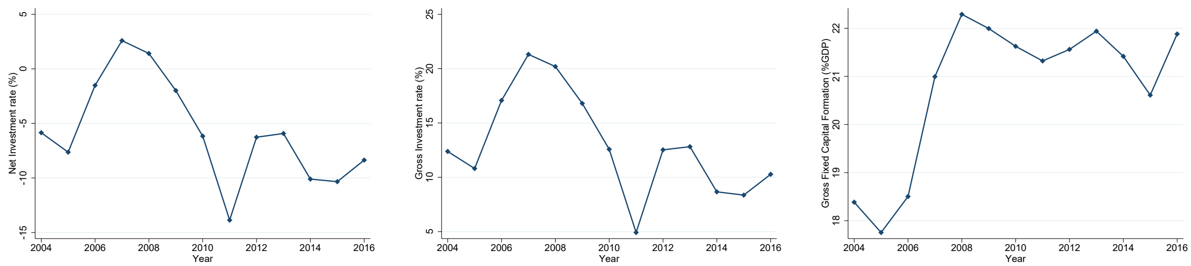
high levels of uncertainty and faltering real activity (Figure 1).

This environment of heightened uncertainty is also reflected in the behavior of gross and net investment rates for the Russian economy (Figure 2). Despite episodes of positive net investment preceding the GFC, net investment rate for the *average* firm is negative for significant parts of the sample. While showing some recovery from the GFC up until 2012, gross and net investment rates declined further in the period after 2014 and never recovered to the values they had obtained in 2007 or even 2004. Thus, the Ukrainian crisis and the onset of sanctions in 2014 caused whatever gains that had been obtained up to 2012 to dissipate.

In this paper, we quantify the effects of uncertainty on the investment behavior in the non-financial sector of the Russian economy over the period 2004-2016. For this purpose, we consider the sanctions regime as a quasi-natural experiment and employ a difference-in-difference estimation strategy. Belin and Hanousek (2020) examine the efficacy of the reciprocal sanctions imposed by Russia and the EU. As in our approach, they justify their quasi-natural experimental approach by

Figure 2: Mean investment rates of non-financial firms, 2004–2016

(a) Net investment rate (b) Gross investment rate (c) Gross investment-GDP



SOURCE: Panels (a) and (b): Orbis-Ruslana database, authors' calculations. Panel (c): OECD, authors' calculations

arguing that the implementation of sanctions against Russia as a policy shock is exogenous to any individual firm.[3] Our analysis differs from these papers in that we study the impact of increased uncertainty associated with the sanctions regime, which is likely to capture the longer term impact of sanctions on the Russian economy rather than the more immediate effects on bilateral trade flows or the activities of targeted firms.

To control for the heterogeneous effects of the ruble devaluation and oil price decline that occurred concurrently with the sanctions regime, we exploit firm-level and sectoral variation by using sector-level data from the OECD Inter-Country Input-Output (ICIO) Tables jointly with our firm-level data set that covers large firms and SMEs. Conducting such an exercise allows us to better identify the impact of uncertainty due to the sanctions regime on investment behavior by isolating it from other general equilibrium-like effects. This identification requires us to assume that any remaining variation in firm-specific demand and supply conditions during the sanctions regime that are not captured by foreign exchange exposure risk, the sanctioned trade channel and oil-cost dependence in production do not vary systematically by the uncertainty prevailing in the Russian economy.

Using an error correction specification implied by an underlying model of investment that allows for investment irreversibility and expandability, we find evidence for the pervasive impact of uncertainty for the Russian economy. In particular, we find significant negative effects of uncertainty on the response of investment to demand shocks due to the sanctions regime after isolating

[3]See also, Crozet and Hinz (2020) and Ahn and Ludema (2020).

the joint effects of foreign exchange exposure that works through balance sheet channel of the ruble devaluation, the effects of the oil-cost dependence in production as well as of the indirect effects of trade linkages with sanctioning countries on the investment rate. The dampening effect of uncertainty on the response of investment to demand shocks arises in a model with partial investment irreversibility and expandability. In such a framework, uncertainty affects investment behavior by increasing the separation between the marginal product of capital which justifies investment and the marginal product of capital which justifies disinvestment. This increases the range of inaction where investment is zero as the firm prefers to "wait and see" rather than undertaking a costly action with uncertain consequences.[4]

To further justify our approach, we initially examine the confounding effects of the different phenomena separately in Sections 5.1-5.2. The period following the imposition of sanctions in 2014 is characterized by 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 (Gurvich and Prilepskiy (2015)). 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. While the investment rate of firms with high foreign exchange exposure is 1.8 percentage points lower as compared to the investment rate of firms with low foreign exchange exposure during the sanctions regime, there is no significant effect on the response of investment to sales growth through the channel of foreign exchange exposure. On the other hand, if firms in the tradable sector versus the non-tradable sector have more resilient balance sheets due to their greater ability to generate foreign exchange currency-denominated income, this may mitigate their negative response to foreign exchange shocks during the sanctions regime. Our results indicate that this is indeed the case, though we find no difference in the response of firms in the tradable sector versus non-tradable sector to demand shocks under the sanctions regime.

Studies that examined the impact of sanctions directly have found their macroeconomic impacts to be typically small precisely because such sanctions were intended to affect the long-term health of

[4]Equivalently, the existence of the real marginal call and put option values in such models make firms more cautious when investing or disinvesting.

Russian companies through their access to credit or technology. (see i.e., Ahn and Ludema (2020)). However, such targeted sanctions may have also have an effect on firm-level investment through their impact on trade linkages with sanctioning countries; see Belin and Hanousek (2020) and Crozet and Hinz (2020) who examine the impact of reciprocal sanctions on bilateral trade flows between the Russian Federation and both sanctioning and non-sanctioning countries. In contrast to these studies, we 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. Relative to firms that operate in the sectors with weaker links, firms that operate in sectors with strong trade linkages based on the imports of intermediate goods with sanctioning countries experience a decline of 5.2 percentage points in their investment rate during the sanctions period. However, there is no evidence that the targeted trade sanctions reduced the response of investment expenditures to demand shocks during the sanctions regime.

The decline in the price of oil that occurred in 2014 may be viewed as another confounding factor for quantifying the impact of uncertainty for Russian non-financial firms. The reduction in the price of oil may have the effect of reducing the revenues for 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. While such aggregate demand-side effects of a decline in the price of oil are captured through year and sector-year fixed effects, we account for potential heterogeneity on the supply side by incorporating an index of cost-side oil dependence in production measured as the share of oil inputs in output in our estimation. We find that the negative impact on the investment of firms operating in high oil-cost dependent sectors is mitigated by 2.1 percentage points relative to those operating in low oil-cost dependent sectors induced by uncertainty associated with the sanctions regime. Second, the response of investment to firm-level demand shocks captured by sales growth during the sanctions regime is also mitigated for firms operating in the sectors with high oil-cost dependence relative to those operating in the sectors with low oil-cost dependence.

In this study we make use of the Ruslana historical product compiled by Bureau van Dijk (BvD). This data provides a comprehensive sample of the Russian economy with a coverage that averages almost 68% for gross value added in the period 2011-2014 relative to that is reported by the Russian statistical agency Rosstat. Further, comparing its share of firm coverage by size class in 2015 with that is reported by the census of small and medium-sized enterprises (SME) conducted by the Russian SME Resource Centre (RCSME), we show that Ruslana data mimics the firm-size distribution in the SME sector of Russia. Hence, it covers not only large publicly-listed firms, as in most of the literature studying investment and employment, but also privately-held firms of different sizes. Following the approach in Kalemli-Ozcan et al. (2019), we construct a rich panel of Russian non-financial firms of different sizes from micro enterprises to SMEs to large firms. 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 characterize the Russian economy over the period 2004-2016.

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 provides a detailed discussion of the results. Section 6 concludes.

2 Literature Review

To begin, our paper relates to the vast literature on investment under uncertainty with irreversibility.[5] Irreversibility and uncertainty generate the gradual adjustment of the capital stock, as observed in the data. Such features also create an option value of investment and the need for caution in making new investment decisions.[6] There is also an extensive literature that has examined the role of uncertainty on irreversible investment decisions using industry- or firm-level data. Using the standard deviation of stock returns as their measure of uncertainty, Bloom et al. (2007) show that higher uncertainty with partial irreversibility reduces the responsiveness of investment to demand shocks.

[5]For extensive surveys, see Dixit and Pindyck (1994), Caballero (1999), Hassett and Hubbard (2002), and Demers et al. (2003), among others.

[6]See Nickell (1978) on the role of delivery lags and timing uncertainty as an explanation of the gradual adjustment of the capital stock and the irreversibility constraint as an explanation of the need for caution or Demers (1991) who introduces the learning behavior of a firm, and shows how output price uncertainty reduces the investment of a Bayesian firm facing irreversibility. Pindyck (1988) develops a model of incremental capacity choice where the firm's value is the sum of the firm's capital in place and of its growth options. Abel and Eberly (1994) introduce costs of adjustment in a model with imperfect resale markets. Bertola and Caballero (1994) investigate aggregation of individual irreversible investment decisions while Caballero and Pindyck (1996) examine industry equilibrium with sunk costs of entry.

They also uncover an additional source of nonlinearity originating from a convex response of investment to demand shocks. Bond and Lombardi (2006a) implement this approach using Italian company data on fixed capital investment.[7]

An empirical literature has also developed to measure economic policy uncertainty and to examine its relation with various aggregate indicators and firm-level investment. Baker et al. (2016a) develop an index of economic policy uncertainty for the US based on the frequency of words such as "economic" and "uncertainty" as well as one word from "Congress", "deficit", "Federal Reserve", "legislation", "regulation" and "White House" in 10 leading US newspapers since 1985. Using the news-based index of policy uncertainty, Gulen and Ion (2015) show that there is a strong negative relationship between firm-level investment expenditures for publicly listed firms and uncertainty associated with future policy and regulatory outcomes. They also find that this relationship is stronger for firms that face a high degree of irreversibility and for ones that are dependent on government spending.[8] In our analysis, we make use of the EPU index developed for the Russian Economy by Baker et al. (2016a), which is constructed from searches based on the Russian financial newspaper Kommerstant's own online archive from 1992 onward; see Baker et al. (2016b).

The sanctions regime instituted against various economic entities in Russia beginning in 2014 is clearly an incidence of heightened uncertainty for the Russian economy. As Kaempfer and Lowenberg (2007) argues, the channels through which sanctions impact economic activity are specific to the nature of sanctions and the political and economic environment prior and during the sanctions regime at the sanctioned country. Dreger and Kholodilin (2016) create a sanctions index for the Russian economy, which is based on a trade-weighted sum of the different types of sanctions implemented against Russian entities, and find that the decline in the price of oil, not sanctions, were

[7]See also Altug et al. (2007), who use a regime switching framework to model irreversible investment behavior under political risk, which they apply to the case of the separation of Quebec province from the Canadian Federation or Fatas and Metrick (1997), who build an aggregate demand externality into an irreversible investment model. Bloom et al. (2018) incorporate general equilibrium considerations into a model with partial irreversibility at the firm level and generate a measure of uncertainty from the the dispersion of plant-level innovations to total factor productivity (TFP). They show that increased uncertainty leads to drops in hiring, investment and output, and causes reallocation effects which are associated with a decline in productivity growth.

[8]Jirasavetakul and Spilimbergo (2018) construct a news-based economic policy uncertainty index for Turkey using foreign newspapers rather than Turkish newspapers as the primary source of news items. Dejuán and Ghirelli (2018) use the measure of policy uncertainty constructed by researchers at the Bank of Spain which combines measures of the cross-sectional dispersion of individuals' expectations and opinions about the current and future political situation, a measure of political risk, the EPU index constructed by Baker et al. (2016a) for Spain, and an indicator of the degree of disagreement in budget deficit forecasts." They find that such uncertainty has adverse effects on investment for non-exporting firms, small and medium enterprises, as well as firms in poorer financial condition.

responsible for the ruble devaluation. Gurvich and Prilepskiy (2015) study the financial channel of sanctions on the Russian economy that are associated with limits on foreign borrowing. 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.[9] Ankudinov et al. (2017) examine the impact of sanctions on the extreme movements and heavy-tailedness properties for Russian stock indices returns.[10] However, these analyses are based on macroeconomic data and do not control for the effect of firm- and sector-specific effects of sanctions in conjunction with changes on oil prices and the exchange rate, an issue that we consider in this paper.

The impact of sanctions imposed by the EU and the US may also be studied through its effect on the bilateral trade flows between Russia and other countries. Belin and Hanousek (2020) examine the efficacy of the reciprocal sanctions imposed by Russia and the EU. They use a difference-in-difference approach to test the hypothesis that an exporter-good pair is affected by the sanctions regime.[11] Crozet and Hinz (2020) use bilateral monthly UN Comtrade trade data to evaluate the export losses from all trading partners-nor just sanctioning ones - in a structural gravity model. They consider the impact of reciprocal sanctions imposed by Russia, on the hand, and the EU and the US, on the other.[12] To identify the channels through which such losses occurred, they use French customs data at the firm- and product-level to show that changes in country risk affecting international transactions are the transmission channel for the decline in exports to Russia by sanctioning countries.

Ahn and Ludema (2020) make use of the firm- and individual-level data from the BvD Orbis

[9] They 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.

[10] 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.

[11] 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 to contracts enacted prior to 2014.

[12] 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 90% is incurred by EU countries.

and LexisNexis World Compliance database to identify a group of sanctioned firms and their subsidiaries and a control group of non-sanctioned firms by collecting the home country and sector of business operation as 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. They employ a difference-in-difference approach to compare the financial performance of targeted firms to their non-targeted peers before and after the imposition of sanctions.[13] Our analysis differs from these papers in that we study the impact of increased uncertainty associated with the sanctions regime, which are likely to capture the longer term impact of sanctions on the Russian economy rather than the more immediate effects on bilateral trade flows or the activities of targeted firms.

3 Data

3.1 Firm-level Data

In our analysis, we obtain firm-level data through the Orbis global commercial data set compiled by BvD—a Moody's Analytics company. Orbis is the largest cross-country firm-level database that covers information on around 300 million firms across the globe. BvD collects data from various sources, in particular, publicly available national company registries, and harmonizes the data into an internationally comparable format. The database has financial accounting information from detailed, harmonized balance-sheets, income statements and profit/loss accounts as well as information on firms' ownership structure, so researchers can use it to link firms' financial accounts, ownership structure and production decisions. The database includes all industries and both private and public firms.[14]

BvD has recently developed a new product, namely the "Historical Product." The historical

[13]They find that targeted firms lost one-quarter of their operating revenue, over one-half of their asset value, and about one-third 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.

[14]Kalemli-Ozcan et al. (2019) underline that this data set is crucially different from other data sets that are commonly used in the literature such as Compustat for the United States, Compustat Global, and Worldscope databases, since 99 percent of the companies in Orbis are private, whereas the former data sets contain mainly information on large listed companies. In Orbis, only less than 2 percent of the firms are publicly listed, which is also separately marketed under the product called Osiris.

product links several vintages/disks of the Orbis data and matches the firm over time using unique firm identifiers. By doing so, it provides several advantages over other studies in the literature that use a single vintage of Orbis database (or a single download from Wharton Research Data Services (WRDS)). One of these advantages is that the historical product has a consistent coverage of firms over time and by industry, whereas a single vintage of Orbis does not. This discrepancy arises due to two reasons. First, Orbis stops tracking a given firm after a certain period of time within a single vintage. Second, the industry classification of a given firm extracted from a single vintage might be misleading. This is because the firm's industry classification might change over time if it expands its operations to new industries and/or its industry classification has been changed by the national statistical offices. Another advantage of using the historical product is that it enables researchers to construct firm-level panel data sets that have financial and real variables including miscellaneous items such as value-added and intermediate inputs for any country of the interest, which is Russia in this paper. However, the firm-level panel data sets constructed based on a single vintage of Orbis database doesn't provide comprehensive information as the historical product does because every vintage doesn't cover all variables.

Due to all these above-mentioned shortcomings, the sample built on a single vintage is not nationally representative, generally under-representing micro and small-sized firms operating in any countries including Russia. Therefore, researchers need to apply imputations and/or re-weighting to obtain firm size distributions that match well with those provided by national statistical agencies. In this paper, we use one of these historical products, which is marketed as "Ruslana".[15] The most important advantage of using this historical product is that we neither impute the data nor apply any re-weighting. For our analysis, we simply download Russian firms from the Ruslana historical product following the guide and programs in the Appendix F of Kalemli-Ozcan et al. (2019), and we construct and clean the data accordingly.[16,17]

[15] The Ruslana historical product contains comprehensive information also on the companies operating in Ukraine and Kazakhstan. In this paper, we focus only on the Russian companies.

[16] We apply additional cleaning steps and quality checks. The details are available in Section B of the Online Appendix.

[17] See Appendix A.1 for the descriptive numbers on the coverage of the Russian data we download from the Ruslana historical product.

3.2 Sector-level Data

In our analysis, we use sector-level data to construct measures of sanctioned trade linkage and oil-cost dependence which we use to control for the heterogeneous effects of uncertainty on investment by Russian non-financial firms.[18] We access the sector-level data from the ICIO Tables for the period 2005–2015.[19] The information from the ICIO Tables is broken to a detailed level information for 36 industries across 69 countries (69^{th} country representing the rest of the world). OECD provides internationally harmonized data by employing an aggregation of 2-digit ISIC Revision 4 codes to 36 sectors which are labelled by the OECD ISIC Codes.[20] For any industry s in a given country c, output is used as either a final good or an intermediate good. To represent this, ICIO consists of two segments. The input-output segment is a matrix of 2484×2484 entries in which the on-diagonal blocks represent domestic transaction flows of intermediate goods and services across industries, while the off-diagonal blocks represent the inter-country flows of intermediates via exports and imports. The final demand segment is composed of 2484 entries for 36 industries of 69 countries. For any industry-country combination, final demand corresponds to the total expenditure on goods and services.

3.3 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 devaluation. We transform nominal financial variables to real using the GDP deflator with 2005 as the base year.

The measures of investment and the determinants of investment we use in our empirical analysis follow seminal papers on this topic. We define the net investment rate as the annual percentage change in the fixed capital stock from the beginning of the period to the end of the period i.e., $\Delta \log(K_{i,s,t})$.[21,22] In the Ruslana database, the fixed capital stock is defined as the firm's the book

[18] See Appendix A.2 for the details on the construction of these sector-level measures.

[19] For further information, see https://www.oecd.org/sti/ind/inter-country-input-output-tables.htm

[20] The industry codes together with their definitions are available in the first two columns of Table A.4.

[21] This definition is also in line with the approximation i.e., $\Delta \log(K_{i,s,t}) \approx (I_{i,s,t}/K_{i,s,t-1}) - \delta_{i,s}$ that we use to develop our baseline linear error correction model discussed in Section 4.

[22] Kalemli-Ozcan et al. (2020) uses the sample of private companies of European countries obtained from ORBIS global database and measures the investment rate in the same manner.

value of gross tangible fixed assets minus depreciation.

In the analysis, we also use the gross investment rate defined as adding sector-specific depreciation rate to the net investment rate. We use the gross investment rate to facilitate the comparison of the investment series constructed based on firm-level Russian data with those obtained from the OECD database depicted in Figure 2. However, the financial statements of Russian firms obtained from the Ruslana database lack information on depreciation expenses. We compensate for this using sector-specific depreciation rates constructed for Spanish sectors. We do so assuming that the mix of fixed assets firms used in their production processes is driven by sector-specific characteristics and that the capital stock accumulated in different sectors may depreciate at a faster or slower rate due to their productive life governed by production and technological parameters prevailing in the given sector.

With this assumption in mind, we construct the sector-specific depreciation rates using the data on Spanish non-financial firms obtained from the Orbis database as follows. First, for each individual firm, we compute the depreciation rate as the ratio of annual devaluation expense by the lagged book value of fixed assets for the given year and compute the time average of the resulting figure for the period 1999–2007.[23,24] Next, we follow NACE Revision 2 industry classification and group the sample into 62 two-digit sectors. For each sector, we calculate the depreciation rate as the median of the depreciation rates of the firms operating in that sector.

Most studies in the literature use Tobin's Q measured as the ratio of market value of total assets to book value of total assets to proxy for profitable growth opportunities. Their analysis is based on large US firms who report information on market values by filing their cash flow statements with Compustat. However, in our empirical framework, we analyze investment decisions of privately held firms that lack information on market values in Orbis. For this reason, to control for the firm's growth opportunities we use the firm's sales growth i.e., $\Delta \log(S_{i,s,t})$ where sales growth is the annual change in the firm's net real sales.[25,26]

[23]Fixed assets comprise gross book value of tangible and intangible fixed assets minus depreciation.

[24]We restrict our estimation of the depreciation rate to this period for two reasons: First, Spanish data have better coverage starting in 1999 as Kalemli-Ozcan et al. (2019) document. Second, we want to exclude the years after the GFC and the sovereign debt crisis in Europe, considering the potential impact of these crises on the dynamics of capital accumulation.

[25]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.

[26]Among others, net sales growth is the most appropriate measure for private firms to proxy profitable growth oppor-

We proxy the firm's profitability using the ratio of cash flow to total assets. We compute cash flow as net income plus depreciation expense.[27]

We capture the firm's leverage using 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.

We also measure the ratio of foreign-currency denominated debt to total assets at the firm-level implementing the steps outlined in Kalemli-Ozcan et al. (2021). The Ruslana database does not break down firm-level 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. 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

tunities and commonly used in recent literature; see, for example, Kalemli-Ozcan et al. (2020).

[27] To construct the firm's annual depreciation expense, we multiply the lagged value of its capital with the corresponding sector-specific depreciation rate that we extrapolate from the Spanish data.

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.[28,29] 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.[30]

Table 1: SUMMARY STATISTICS, 2004–2016

Variable	Obs.	Mean	Std. Dev.	Min.	Median	Max.
Gross investment/Capital	452,910	0.1226	0.3821	-0.6529	0.1810	1.2278
Net investment/Capital	452,910	-0.0648	0.3794	-0.8428	0	1.0427
Cash flow/Assets	452,910	0.0524	0.1837	-0.4063	0.0245	0.4746
Sales growth	419,610	-0.0905	0.5643	-1.6574	0	1.1676
FX debt/Assets	452,910	0.0316	0.0620	0	0	0.2956
Financial leverage	452,910	0.2744	0.5577	0	0	2.9971
Leverage	452,910	0.7463	0.6648	0	0.7138	2.7368

NOTES: Table 1 reports summary statistics of the firm-level variables we use in our empirical analysis.

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 has a mean of %12.26 and a median of %18.10. However, net investment rate has a mean of %-6.48 and a median of 0, attesting to the anemic investment performance of firms in the Russian non-financial sector over the sample period of 2004-2016. Sales growth which is used to capture profitable growth opportunities has a mean of -0.0905 and standard deviation of 0.5643, and varies between a minimum of -1.6574 and a maximum of 1.1676. 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 0.0524 with a standard deviation of 0.1837. Financial leverage has mean of 0.2744 and varies between 0 and 2.9971 while the ratio of FX debt to assets is 0.0316 on average with a maximum value of nearly 0.30. Leverage which is used to capture all types of debt has a higher mean of 0.7463, suggesting that non-financial debt including trade credit constitutes a significant

[28] 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.

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

[30] The results obtained using this alternative FX debt measure remain robust. We don't present them here considering space limitations, they are available upon request.

Table 2: COMPARING MEANS BY FIRM SIZE

	FX Exposure		Sanctioned Trade Linkage		Oil-Cost Dependence	
	Large	Small	Large	Small	Large	Small
	(1)	(2)	(3)	(4)	(5)	(6)
Mean	0.38	0.29	0.077	0.068	0.52	0.33
Test mean difference	(-43.17)		(-24.19)		(-53.13)	

NOTES: Table 2 presents the mean values of the variables FX Exposure, Sanctioned Trade Linkage and Oil Cost Dependence by firm size, 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 in the top quartile of the distribution of firm size which is measured by logarithm of the firm's total assets. FX Exposure is measured by the ratio of FX debt to total assets. Sanctioned Trade Linkage measures the ratio of intermediate inputs imported from sanctioning countries in total inputs from abroad for a given sector. Oil-cost Dependence measures the ratio of oil inputs in total output for a given sector. See Sections 3.3 and 3.2 for further details on the construction of these variables. t-statistics of the t-tests that we use to compare size-based group means are given in the parentheses.

portion of the debt of an average Russian non-financial firm.

As described in detail in Section A.1.1, our data obtained from BvD's Ruslana historical product mimics the firm-size distribution in the SME sector of the Russian economy. Using this data, we construct a representative panel of Russian non-financial firms that covers not only large companies, also micro enterprises and SMEs. The usage of such a rich sample enables us to account for unobserved heterogeneity associated with firm size in our empirical analysis. This is important because firms of certain sizes might behave in a different manner, which might then drive the relationship between firm investment and observed changes in foreign exchange rate as well as oil price during the sanctions regime, leading to imprecise inference on these relationships of our interest.

Table 2 shows how large and small firms differ on average in terms of their FX exposure, sanctioned trade linkages, and oil-cost dependence. First, in this table, Columns (1)–(2) show that, on average, large firms hold higher ratios of FX debt as compared to small firms. This observed variation in terms of FX exposure can be attributable to permanent differences between large and small firms such as the higher ratio of foreign currency assets in total assets. Large firms might be better able to pledge these assets as collateral, easing their access to FX denominated financing. Further, large firms can have a stronger reputation in international capital markets or access better information about international capital markets. Such time-varying unobserved heterogeneity might also potentially explain the above-mentioned variation in terms of FX exposure.

Second, in the same table, Columns (3)–(4) suggest that, on average, large firms happen to operate in the sectors with stronger trade linkages with sanctioning countries. This arises from the fact that engaging in trade with entities in the EU and the US most likely requires firms to be of a certain size to access trade networks, obtain trade credit from foreign suppliers, and have stronger organizational abilities to acquire information and comply with international tax and regulatory codes. Third, according to the means of oil-cost dependence presented in Columns (5)–(6), large firms are shown to operate in the sectors with higher oil-cost dependence. This may have to do with the fact that larger firms typically require more complex production and distribution chains, thereby increasing oil and energy consumption.

3.3.1 Investment Behavior using Firm-level Data

One of the main rationale for using data at fine degrees of disaggregation is to capture variation in investment behavior that involves disinvestment, inaction, and positive investment, as predicted by our theoretical framework. In this section, we present a breakdown of investment decisions by firms based on different categories of aggregation.

Table 3 provides a breakdown of investment decisions by firms based on different categories of aggregation. We observe that there is a significant fraction of firms by each category that are either engaging in disinvestment or are inactive in any given year. Disinvestment or inaction appears to be a salient response for firms that employ 10-49 employees identified either according to the Eurostat categorization of an SME or by Bond and Lombardi (2006b). Here we observe that 82% of firms with 10-249 employees either disinvest or are inactive in their investment response over the sample period. This fraction falls to 73% when we consider firms with 250 or more employees. In terms of sectors, excluding the services sectors, construction appears to be the sector that suffers from the highest incidence of disinvestment and inaction. According to the data in Table 3, 83% of construction firms either engage in disinvestment or inaction, attesting to to strongly cyclical nature of this sector. This is followed by firms in the manufacturing sector, with close to 81% of firms engaged in some form of disinvestment or inaction.

Table 3: INVESTMENT BEHAVIOR OF RUSSIAN NON-FINANCIAL FIRMS, 2004–2016

	Disinvestment	Inaction	Investment
Panel A: By size group			
Micro (0-9)	30862	104854	8782
SMEs (10-249)	150298	87544	51144
Large $\geq$ 250)	13270	945	5203
Panel B: By size group			
EMPL 0-9	30862	104854	8782
EMPL 10-49	100198	77607	29361
EMPL 50-99	30807	7618	13405
EMPL 100-199	16306	1917	7253
EMPL 200-499	9953	1134	3642
EMPL 500-999	3705	144	1501
EMPL $\geq$ 1000	2599	69	1185
Panel C: By sector			
Agriculture	16957	5688	7010
Mining	2334	1363	1160
Manufacturing	26298	14646	9617
Utilities	6024	1705	2363
Construction	22926	21531	8991
Non-financial market services	115293	142368	34634
Non-financial non-market services	4601	6047	1354
IV. Other			
State-owned	8829	868	2463
Energy	576	337	371

NOTES: In Panels A-D, we summarize the investment behaviour of Russian non-financial firms by size group, by sector and by ownership. In the first two panels, we follow the definitions of Eurostat and Bond and Lombardi (2006b) to group firms according to their size respectively. In Panel C, we use NACE Revision 2 industry classification to group firms by sector. We break down Russian service industry into the two broad categories. Non-financial market services is comprised of "Accommodation and food services;" "Information and communication;" "Real estate activities;" "Professional, scientific and technical activities;" and "Administrative and support services activities." Non-financial non-market services is comprised of "Public administration and defence; compulsory social security;" "Education;" "Human health and social work;" "Arts, entertainment, recreation and other service activities." In Panel D, we label firms "energy" if they pursue oil and energy related activities. For further details, see Section B.5 of the Online Appendix. We label firms as "state-owned" if they are owned by the Russian state as well as local municipalities and public bodies that operate in the Russian Federation.

4 An Empirical Framework

In this section, following Bloom et al. (2007) we develop an error correction model of investment that can be used to examine empirically the impact of uncertainty on firm-level investment.[31] The relevance of the underlying model of partial irreversibility and expandability is that it allows us to investigate the episodes of investment and disinvestment that we document in Section 3.3.1 using our firm-level data.

[31]The Online Appendix describes a partial equilibrium model of a firm that faces partial irreversibility and partial expandability in its investment/disinvestment decisions that underlies this empirical framework. See Abel et al. (1996) or Demers et al. (2003) for a further elaboration of this model.

In his analysis, Bloom (2000) shows that the capital stock chosen by a firm in a model with partial irreversibility has a growth rate that is equal to the capital stock chosen by a firm with costless reversibility, implying that the logarithms of the two series are cointegrated.[32] This cointegration result may be expressed as

$$\log(K_{i,s,t}) = \log(K^{*}_{i,s,t}) + \epsilon_{i,s,t}, \tag{1}$$

where $K_{i,s,t}$ is the actual capital stock of firm i operating in sector s at time t, $K^{*}_{i,s,t}$ is the capital stock that would have been chosen under costless reversibility, and $\epsilon_{i,s,t}$ is a stationary error term. Under the assumption of a constant returns to scale production function and isoelastic demand, the frictionless capital stock of the firm depends on the Jorgensionian user cost of capital and a composite variable that reflects "demand conditions." Under the assumption that such demand conditions are proportional to the firm's sales denoted by $S_{i,s,t}$, the frictionless capital stock is written as

$$\log(K^{*}_{i,s,t}) = \log(S_{i,s,t}) + \mu^{*}_{i} + \zeta^{*}_{t}, \tag{2}$$

where μ^{*}_{i} and ζ^{*}_{t} represent unobserved firm-specific and time-varying components and response to variation across firms in the user cost of capital.

The basic error correction model that approximates the relationship between the actual capital stock and the frictionless capital stock is given by

$$\Delta\log(K_{i,s,t}) = \beta_1\Delta\log(S_{i,s,t}) + \theta\log(\mathrm{S}_{i,s,t-1}/\mathrm{K}_{i,s,t-1}) + \mu_i + \zeta_t + \epsilon_{i,s,t}, \tag{3}$$

where μ_i and ζ_t are unobserved firm-specific and time-specific effects and $\epsilon_{i,s,t}$ is an error term that should be serially uncorrelated in an approximate sense. Here a positive value for the coefficient θ implies that firms that are below their target level of capital will adjust upwards and vice versa.

As discussed in the Introduction, the Russian economy has been subject to the effects of high and volatile uncertainty over the entire sample period, 2004–2016. Moreover, such uncertainty measured by the annual average value of the monthly EPU index increased by 66% over the period 2014–2016

[32] This results from the fact that the firm's marginal revenue product is bounded by two trigger values that represent the cost of capital with partial irreversibility and expandability; see Abel and Eberly (1996).

compared to its value for the period 2004–2013 (see; Panel (a) in Figure 1).[33] In a related analysis, Gulen and Ion (2015) capture the impact of uncertainty on investment decisions at the firm level through inclusion of the current value of the EPU index, and measure the degree of irreversibility of firms' investments using such proxies as the the ratio of net value of property, plant and equipment (PPE) to total assets.[34] They also control for the effects of firm-level and macroeconomic variables that might capture future investment opportunities or economic uncertainty that is erroneously attributed to the EPU index.

In the underlying model of partial irreversibility and expandability, firms act more cautiously in their response to increases in sales growth in an environment with greater uncertainty. To capture this effect, we include an interaction term between a measure of uncertainty, namely, the current value of EPU Index and current sales growth i.e., $\Delta \log(S_{i,s,t})$ into equation (3).[35] In the model of that underlies our approach, investment occurs when the firm's marginal revenue product of capital (MRPC) hits an upper threshold, given by the traditional user cost of capital plus an option value for investment. Similarly, disinvestment only occurs when the firm's MRPC hits a lower threshold, given by the user cost for selling capital less an option value for disinvestment. Thus, the existence of the real marginal call and put option values in such models make firms more cautious when investing or disinvesting.

We also include a quadratic term in sales growth to capture the convex response of investment to positive demand shocks and the concave response to negative demand shocks; see Bloom et al. (2007). We include a cash flow variable Cash $\text{Flow}_{i,s,t}$ as an additional control to capture the impact of financing constraints (see Fazzari et al. (1988)).

The baseline linear error correction model is obtained as follows

$$\begin{aligned}(I_{i,s,t}/K_{i,s,t-1}) &= \beta_1 \text{EPU}_{t-1} \times \Delta \log(S_{i,s,t-1}) + \beta_3 \Delta \log(S_{i,s,t-1}) + \beta_4 (\Delta \log(S_{i,s,t-1}))^2 \\ &+ \beta_5 \text{Cash Flow}_{i,s,t-1} + \theta \log(S_{i,s,t-2}/K_{i,s,t-2}) + \mu_i + \mu_{s,t} + \epsilon_{i,s,t}, \end{aligned} \tag{4}$$

where $(I_{i,s,t}/K_{i,s,t-1})$ is the net investment-capital stock ratio for firm i operating in sector s at date

[33] The annual EPU index is renormalized to a mean of 100 from 2004 to 2016.

[34] Other approaches include using the extent of sunk costs, the existence of resale markets, or the cyclicality of industries.

[35] In Bloom et al. (2007), such effects are captured through the standard deviation of firm stock returns.

t,[36] EPU_{t-1} is measured as the natural logarithm of annual average value of the monthly uncertainty index depicted in Figure 1-(a) at date $t-1$, $\Delta \log(\text{S}_{i,s,t-1})$ is the firm's sales growth in sector s at time $t-1$, $\log(\text{S}_{i,s,t-2}/\text{K}_{i,s,t-2})$ is the lagged error correction term, and Cash $\text{Flow}_{i,s,t-1}$ is the firm's lagged cash flow-total assets ratio. Finally, μ_i and $\mu_{s,t}$ captures firm-fixed effects and sector-year fixed effects, respectively.

While the specification in equation (4) includes an interaction term between the EPU index and firm-level sales growth, it does not include the level of the EPU index. This is in contrast to Gulen and Ion (2015), who also consider specifications that incorporate the level of the EPU index. Instead, we include year and 4-digit sector-year fixed effects which absorb the level effect of the EPU index. This enables us to deal with potential endogeneity issues due to the existence of omitted investment predictors and other indicators of economic policy uncertainty that might be correlated with the EPU index. In this specification, 4-digit sector-year fixed effects control for any unobserved time-varying heterogeneity at different sectors defined at a very fine 4-digit level that might affect firms' investment behavior that are not captured by the investment predictors observed in the data. These 4-digit sector-year fixed effects also account for permanent differences across sectors as well as macroeconomic shocks and policy changes that are cross-sectionally invariant as they include sector dummies and year dummies by construction. Further, the firm-specific effects control for unobserved, time-invariant firm-level heterogeneity. For instance, if net investment to capital ratio is lower on average for the firms with risk averse managers who tend to be cautious in undertaking new investment, such firms will be affected differently by a change in any investment predictors as well as economic policy uncertainty. In the estimation, the firm fixed effects will absorb this average effect, preventing it from driving our results.

We estimate equation (4) using the unbalanced panel data of Russian non-financial firms with all above-mentioned fixed effects. Moreover, there may exist potential endogeneity concerns stemming from reverse causality. In this case, while higher uncertainty leads to a reduction in firm-level investment, declines in investment rates in the economy could also lead to an increase in uncertainty measured by the EPU index. Likewise, this bi-directional effect could also occur for other firm-level investment predictors such as sales growth or the ratio of cash flow to assets. To avoid any potential

[36] We use the approximation $\Delta \log(\text{K}_{i,s,t}) \approx \text{I}_{i,s,t}/\text{K}_{i,s,t-1} - \delta_i$ to write equation (3) in terms of the net investment rate

Table 4: THE IMPACT OF UNCERTAINTY ON INVESTMENT

Dependent variable: $I_{i,s,t}/K_{i,s,t-1}$

	(1)	(2)	(3)	(4)
$EPU_{t-1} \times \Delta\log(S_{i,s,t-1})$		-0.0548***		-0.0619***
		(0.007)		(0.007)
$\Delta\log(S_{i,s,t-1})$	0.0861***	0.3347***	0.0827***	0.3639***
	(0.003)	(0.032)	(0.003)	(0.034)
$(\Delta\log(S_{i,s,t-1}))^2$	0.0321***	0.0286***	0.0324***	0.0286***
	(0.003)	(0.003)	(0.003)	(0.003)
$\log(S_{i,t-2}/K_{i,t-2})$	0.0844***	0.0850***	0.0844***	0.0852***
	(0.001)	(0.001)	(0.001)	(0.001)
Cash $Flow_{i,s,t-1}$	0.0448***	0.0463***	0.0402***	0.0418***
	(0.009)	(0.009)	(0.009)	(0.009)
Firm FE	yes	yes	yes	yes
Sector-year FE	no	yes	no	yes
Year FE	yes	yes	yes	yes
Obs.	156,550	156,550	155,534	155,534
R^2	0.32	0.32	0.35	0.35
Adjusted-R^2	0.14	0.14	0.14	0.14
Within-R^2	0.045	0.045	0.044	0.045

NOTES: Table 4 reports the results of estimation of the equation (4). I/K is the firm's net investment-capital stock ratio. EPU is measured as the natural logarithm of annual average value of the monthly uncertainty index developed by Baker et al. (2016a) for Russia. $\Delta\log S$ is the firm's sales growth. $\log(S/K)$ is the error correction term. Cash Flow is the firm's cash flow-total assets ratio. Heteroskedastic-consistent standard errors clustered at firm level are reported in parentheses.***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

endogeneity bias associated with such phenomena, we estimate the equation (4) with all right-hand side variables lagged one period.[37]

Column (1) in Table 4 presents results for a basic error correction model represented by equation (3) with additional cash flow term and squared sales growth term. We find that the coefficients of all investment predictors are estimated with the sign implied by the basic linear error correction model. First, the coefficient on the error-correction term is significant and positively signed, suggesting that firms adjust the long-run value of their capital stocks towards a target that is proportional to firm sales, as in Bloom et al. (2007). Sales growth enters positively, capturing the positive effect of growth opportunities that are associated with positive firm-level demand shocks. A positive coefficient on the squared term suggests a convex relationship between investment and positive demand shocks and a concave relationship between investment and negative demand shocks. We also find that the cash flow term enters positively, suggesting the cash-flow sensitivity of investment by Russian non-financial firms, a result which has been taken as signifying the existence of financ-

[37]We also estimate this equation using the Generalized Method of Moments (GMM) procedure and obtained similar results.

ing constraints facing firms (see Fazzari et al. (1988)) or expectations of future demand growth or profitability or other unaccounted factors (see Bloom et al. (2007)).

Further, in Column (2), we add the interaction term between sales growth and the EPU index whose coefficient is estimated to be negative. This finding is consistent with the model of partial investment irreversibility and expandability, as firms "wait and see" implied by model rather than undertaking a costly action with uncertain consequences. The results in Columns (1) and (3) remain unchanged when we include 4-digit sector-year fixed effects, as illustrated in Columns (2) and (4). These results suggest that the basic error correction model of investment postulated by Bloom et al. (2007) is able to capture the dampened response of investment to positive demand shocks under uncertainty. However, as we discussed in the Introduction, the period after 2013 was also accompanied by a large devaluation of the currency together with a decline in the price of oil. These factors may also have affected firm-level investment through alternative channels, which are not captured by our basic specification in equation (4). We now turn to an alternative approach for dealing with this issue, the details which we explain below.

5 The Sanctions Regime as a "Quasi-Natural Experiment"

In the literature, the sanctions regime has been used to justify a quasi-natural experimental approach by arguing that the implementation of sanctions against Russia as a policy shock that is exogenous to any individual firm.[38] In our analysis up to this point, we have not made use of this notion. While the behavior of the EPU index in the post-2014 period is able to capture episodes of heightened uncertainty for the Russian economy, this could arise from confounding effects of omitted factors such as ruble devaluation, sanctioned trade linkages of firms or oil price declines.

In what follows, we use a difference-in-difference type approach to control for the confounding effects of phenomena such as ruble devaluation and oil price changes as well as the targeted sanctions in the pre- and post-2014 periods. Using this approach, we further examine whether the implications of our underlying model under uncertainty are altered by these factors. For this pur-

[38] The sanctions regime instituted against Russia in 2014 included sanctions against individuals and entities as well as sectoral sanctions that "prohibited engaging in certain kinds of transactions, such as longer term financial transactions or the transfer of certain types of specialized technologies and services," see Ahn and Ludema (2020).

pose, we exploit the differences in firm-specific characteristics such as holdings of foreign exchange-denominated debt and sector-specific characteristics such as high linkages in the trade of intermediate inputs with sanctioning countries or high oil-cost dependence of Russian non-financial firms between the pre- and post-sanctions period. In the latter two cases, we consider the behavior of non-energy producing firms, as the sanctions directly targeted the activities of energy-producing companies by banning foreign direct investments and the import of intermediate inputs in areas such as shale oil and deep water and Arctic drilling.[39]

5.1 The role of foreign exchange exposure

As we discussed in the Introduction, the advent of sanctions in Russia was accompanied by a large exchange rate devaluation and a transition to a floating exchange rate regime.[40] Furthermore, one of the main forms of sanctions that was imposed on the Russian economy by the US and the EU was on borrowing by large banks and financial entities in Russia. This may have the effect of tightened credit for Russian companies, especially those borrowing in foreign currency.[41] In what follows, we seek to control for the confounding effect of ruble devaluation as well as direct sanctions on banks and financial institutions on the level of firm-level investment due to tighter financial conditions that firms may face during the sanctions regime as a result of their higher FX debt exposure. Second, we seek to understand the effect that such higher FX exposure has on the response of firms to positive demand shocks in an environment of uncertainty.

The existing literature has identified several channels through which foreign exchange exposure could impact the investment behavior of firms directly (see, for example, Banerjee et al. (2020)). According to the interest rate channel, exchange rate devaluation may be accompanied by negative capital flows. If these flows are exogenous to a country's fundamentals, as they are for most emerging market economies, this will lead to an increase in interest rates, raising the borrowing cost in

[39] As an example, ExxonMobil was forced to withdraw completely from its collaboration with Rosneft in all its Arctic licenses; see Henderson (2015). While the EU sanctions are 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.

[40] Between July, 2014 and February, 2016, the value of the Russian ruble fell from 34.64 rubles per US dollar to 77.22 rubles per US dollar before stabilizing at a somewhat higher rate.

[41] According to Welt et al. (2020), large Russian Sberbank, VTB, Gazprombank, VEB, Russian Agricultural Bank faced prohibitions from issuing debt or equity in foreign financial markets.

the private sector and reducing investment. Second, according to the firm balance sheet channel, an exchange rate devaluation could result in a decline in firms' borrowing and capital expenditures. This is because an exchange rate devaluation can be considered as a negative net worth shock that increases the value of foreign-currency denominated debt, but lowers the value of assets denominated in local currency, thus leading to a tightening of financial conditions (see, for example, Aguiar (2005) and Kalemli-Ozcan et al. (2021)). Third, according to the bank lending channel, contractionary effects of exchange rate devaluation are associated with currency mismatches in the balance sheets of global banks holding liabilities in US dollars that exceed assets in US dollars.[42] A priori, we expect firms that have higher FX debt exposure to decrease their investment more due to tighter financial conditions they face during the sanctions regime. Further, firms that are exposed to foreign exchange risk might be expected to have further dampened responses that reflect the interaction of the wait-and-see with the exchange rate risk channel.

To test these predictions, we extend the baseline investment equation (4) as follows

$$
\begin{aligned}
(\mathrm{I}_{i,s,t}/\mathrm{K}_{i,s,t-1}) \;=\;& \beta_1 \mathrm{Post}_t \times \mathrm{FX}_{i,s} \times \Delta\log(\mathrm{S}_{i,s,t-1}) + \beta_2 \mathrm{Post}_t \times \Delta\log(\mathrm{S}_{i,s,t-1}) \\
&+ \beta_3 \mathrm{Post}_t \times \mathrm{FX}_{i,s} + \beta_4 \mathrm{Post}_t \\
&+ \beta_5 \mathrm{FX}_{i,s} \times \Delta\log(\mathrm{S}_{i,s,t-1}) + \beta_6 \mathrm{X}_{i,s,t-1} + \mu_i + \mu_{s,t} + \epsilon_{i,s,t}, \qquad (5)
\end{aligned}
$$

where $(\mathrm{I}_{i,s,t}/\mathrm{K}_{i,s,t-1})$ is the investment-capital stock ratio for firm i operating in sector s at date t, $\Delta\log(\mathrm{S}_{i,s,t-1})$ is the firm's sales growth in sector s at time $t-1$, $\mathrm{X}_{i,s,t}$ is a matrix that contains the investment predictors used in the estimation of the baseline investment equation that we outline in the previous section. As discussed in Section 4, we include a progressively broader set of fixed effects such that first, we include firm fixed effects, then we consider firm-specific and year fixed effects. Finally, we include sector-year fixed effects.

In this specification, $\mathrm{FX}_{i,s}$ is a dummy variable that equals one for the firms in the top quartile of the FX exposure distribution. As explained in Section 3.3, we proxy FX debt exposure by the firm's foreign-currency denominated debt to total assets. In the estimation, we use this proxy in the form

[42] When the home currency depreciates vis-a-vis the US dollar, the value-at-risk constraint that the global banks face will tighten, leading to a decline in the credit supply globally (see, Bruno and Shin (2015)). Further, a large devaluation or devaluation in the home country may also affect local banks' net worth, reducing the lending ability of those banks in terms of foreign currency.

of a dummy variable, not as a continuous variable. By doing so, we are able to identify the firms with high FX exposure thanks to this dummy variable in the interaction specification, which facilitates the interpretation of the coefficients of our interest i.e., β_1 and β_3. Further, the variable $\text{FX}_{i,s}$ is a predetermined firm-level dummy that equals one for the firms in the top quartile of the FX exposure distribution at any time during three years prior to the year the sanctions regime is instituted. This removes the concerns regarding the selection problem that arises from the possibility that the ranking of firms in the distribution of FX debt exposure variable might change as a consequence of the ruble devaluation during the sanctions regime.[43] Post_t is a dummy variable that equals one in 2014, which corresponds to the year when the sanctions regime is instituted, and onward. The interaction variable i.e., $\text{Post}_t \times \text{FX}_{i,s}$ is the simple multiplication of these two dummy variables. We multiply this interaction term further with the firm's sales growth i.e., $\text{Post}_t \times \text{FX}_{i,s} \times \Delta \log(\text{S}_{i,s,t-1})$. However, we are not able to test the direct effect of $\text{FX}_{i,s}$ on investment because $\text{FX}_{i,s}$ is a predetermined firm-level dummy, which is absorbed by firm fixed effects.

We interpret the coefficients in equation (5) in the following manner: For given levels of investment predictors including the firm's sales growth, β_3 captures the relative effect of the ruble devaluation that occurred together with the sanctions regime on the investment behaviour of Russian non-financial firms through their high FX debt exposure. Thus, β_3 compared to β_4 is the incremental effect on investment of being a firm with high FX debt exposure during the sanctions regime. β_1 captures the response of firms holding high FX debt to positive demand shocks proxied by firm-level sales growth under the higher uncertainty during the sanctions regime. Hence, β_1 compared to β_2 is the incremental effect during the sanctions regime of being a firm with high FX debt exposure on the response of investment to positive demand shocks.

In Panel A of Table 5, we estimate the effect of FX debt exposure on the investment response of firms during the sanctions regime for the full sample of firms. While Column (1)–(2) show that firms holding higher levels of FX debt invest less than firms with low levels of FX debt, this effect is doubled in Column (3), where we control for 4-digit sector-year fixed effects. This finding suggests that in the absence of such sector-year fixed effects, the estimation potentially misses firms with high FX debt exposure operating in the 4-digit sectors that are hit by positive terms-of-trade shocks and

[43] In the years when the sanctions regime is in place, only 8.6 percent of observations changed the level of FX debt exposure from low to high.

that increase their investment rate by exploiting competitiveness effects during an episode of large ruble devaluation. Therefore, the inclusion of these sector-year fixed effects is crucial for controlling for the above-mentioned selection. Thus, according to Column (3), for a given level of sales growth as well as of other investment predictors, firms with high levels of FX debt exposure have a 2.47 percentage points lower net investment rate during the sanctions regime as compared to firms with lower levels of FX debt exposure.

Next, we consider the estimates of β_2. The negative and significant estimates displayed in Columns (1)-(3) indicate that Russian non-financial firms display cautious behavior in their investment response to demand shocks under greater uncertainty associated with the sanctions regime. However, β_1 not being statistically different from zero suggests that the investment of firms with high levels of FX debt doesn't respond differently to positive demand shocks than that of those with low levels of FX debt.

We extend the results in Table 5 by noting that firms operating in certain 4-digit sectors may behave in the opposite way during large devaluations. First, the standard trade channel states that the ruble devaluation will make the price of Russian goods cheaper and increase exports, potentially leading to an expansion of investment and economic activity. However, the existence of imported inputs may also have an opposite effect. As Halpern et al. (2015) shows, imported inputs lead to an increase in productivity through having a higher price-adjusted quality and through imperfectly substituting for domestic inputs. If imported inputs become more expensive, this channel may counteract the positive effect on investment of having a cheaper ruble due to a significant decline in productivity as shown in Gopinath and Neiman (2014). Hence, the impact of the ruble devaluation on investment that is transmitted through trade channel differently across different four-digit sectors is mitigated to the extent their export activities dominate their import dependence.

Further, if firms operating in the sectors whose exports strongly dominate their imports, the negative impact of FX exposure risks on the investment of such strong "net exporters" would be mitigated relative to that of firms operating in the sectors where exports weakly dominate their imports or imports strongly dominate exports. This is possible because such sectors with high net trade dependence are able to generate high levels of FX currency-denominated revenues. Consequently, the investment of such firms might be less responsive to exchange rate fluctuations thanks to their higher net worth. Therefore, we further investigate how the investment behaviour of firms with high FX debt exposure differentiates with being a firm in tradable sector by grouping our sample of Russian non-financial firms into the tradable and non-tradable sectors.[44]

Table 5 illustrates the estimation results for these two sector groupings in Panels B-C, respectively. Column (3), which is the preferred specification, suggests that holding a high level of FX debt leads to a significant negative effect on the investment expenditures by Russian non-financial firms operating in the non-tradable sector: the coefficient β_3 in equation (5) estimated to be -0.0325, suggesting a decline of 3.25 percentage points in the net investment rate for firms in the non-tradable sector holding high level of FX debt. By contrast, the estimate is found to be not statistically different from zero for investment by Russian non-financial firms operating in the tradable sector. Further, we find that the impact of holding high levels of FX debt on the response of investment to sales growth for firms either in the tradable or non-tradable sectors is not statistically significant from zero.

In Column (4) of Table 5, we add a fixed effect to control for firm size. As discussed in Section 3.3, large and small firms differ in terms of their FX debt exposure, with large firms holding more FX denominated debt on average. This observed variation may be attributable to a variety of factors, including permanent differences across firms with different size such as pledgeability of FX-denominated collateral, easier access to FX financing in local and international markets due to their stock of reputation, among others.[45] In order to control for these systematic differences between large and small firms, we add Large-year fixed effects to our estimation where Large is a predetermined firm-level dummy variable that equals one for the firms that are ranked in the top quartile of the firm size distribution at any time during three years prior to the year when sanctions regime is instituted.[46] We measure firm size by the logarithm of the firm's total assets. The Large-year fixed effects absorb the effects of holding FX debt higher than average by large firms relative to smaller ones. Hence, the result in Column (4) shows that the negative effect of high FX debt exposure is reduced once we explicitly control for firm size through the inclusion of the Large-size fixed effects.

[44]We do this grouping on the basis of the selection of the 10 industries defined in the SNA 2008. Tradable sectors include: agriculture (A), industry (B,C,D,E), information and communication (J), and other services (R,S). Non-tradable sectors include construction, distributive trade, repairs, transport, accommodation, food services activities (G,H,I), real estate activities (L), business services (M,N), and public administration (O,P,Q).

[45]However, our data set does not provide a breakdown of assets by currency denomination; hence, we cannot use FX denominated collateral as an observable control in regressions, instead using large firm dummies to account for such potentially permanent differences across firms in terms of their FX debt exposure.

[46]In the years of the sanctions regime only 7.6 percent of observations changed the level of firm size from small to large.

Table 5: The Role of FX Debt Exposure

Dependent variable: $I_{i,s,t}/K_{i,s,t-1}$

	Panel A: All Firms					Panel B: Firms in the Tradable Sector					Panel C: Firms in the Non-tradable Sector				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
$\text{Post}_t \times \text{FX}_{i,s} \times \Delta\log(\text{S}_{i,s,t-1})$	-0.00144	-0.00039	0.00118	0.00083	0.00137	0.00373	0.00509	0.01219	0.01252	0.01272	-0.00673	-0.00568	-0.00904	-0.00974	-0.00903
	(0.009)	(0.009)	(0.010)	(0.010)	(0.010)	(0.014)	(0.014)	(0.015)	(0.015)	(0.015)	(0.013)	(0.012)	(0.013)	(0.013)	(0.013)
$\text{Post}_t \times \Delta\log(\text{S}_{i,s,t-1})$	-0.02796***	-0.02813***	-0.03251***	-0.03168***	-0.03389***	-0.02132**	-0.02230**	-0.02494**	-0.02472**	-0.02554**	-0.03095***	-0.03138***	-0.03511***	-0.03384***	-0.03639***
	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
$\text{Post}_t \times \text{FX}_{i,s}$	-0.01203**	-0.01231**	-0.02465***	-0.01906**	-0.01763**	-0.00979	-0.01079	-0.01297	-0.01250	-0.01190	-0.01804**	-0.01729**	-0.03246***	-0.02430**	-0.02280**
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.008)	(0.008)	(0.009)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Post_t	-0.10959***					-0.09634***					-0.11541***				
	(0.003)					(0.005)					(0.004)				
$\text{FX}_{i,s} \times \Delta\log(\text{S}_{i,s,t-1})$	0.00190	0.00155	0.00262	0.00261	0.00235	-0.00818	-0.00955	-0.00948	-0.01012	-0.01022	0.01023	0.01019	0.01242	0.01280	0.01249
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
$\Delta\log(\text{S}_{i,s,t-1})$	0.09785***	0.09725***	0.09496***	0.09413***	0.09510***	0.09856***	0.09941***	0.09420***	0.09413***	0.09449***	0.09762***	0.09661***	0.09522***	0.09396***	0.09509***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.007)	(0.007)	(0.008)	(0.008)	(0.008)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
$(\Delta\log(\text{S}_{i,s,t-1}))^2$	0.03116***	0.03032***	0.02993***	0.02986***	0.02997***	0.03589***	0.03531***	0.03400***	0.03386***	0.03390***	0.02904***	0.02799***	0.02849***	0.02855***	0.02868***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
$\log(\text{S}_{i,t-2}/\text{K}_{i,t-2})$	0.08632***	0.08604***	0.08627***	0.08612***	0.08613***	0.08962***	0.08900***	0.08928***	0.08921***	0.08922***	0.08537***	0.08522***	0.08537***	0.08519***	0.08518***
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$\text{Cash Flow}_{i,s,t-1}$	0.05099***	0.04488***	0.04243***	0.04235***	0.02796**	0.06338***	0.05258***	0.05388***	0.05430***	0.04926**	0.04580***	0.04102***	0.03728***	0.03712**	0.02008
	(0.009)	(0.009)	(0.009)	(0.009)	(0.012)	(0.015)	(0.015)	(0.016)	(0.016)	(0.021)	(0.011)	(0.011)	(0.011)	(0.011)	(0.015)
Firm FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year FE	no	yes	yes	yes	yes	no	yes	yes	yes	yes	no	yes	yes	yes	yes
Sector-year FE	no	no	yes	yes	yes	no	no	yes	yes	yes	no	no	yes	yes	yes
Large-year FE	no	no	no	yes	yes	no	no	no	yes	yes	no	no	no	yes	yes
$\text{Post}_t \times \text{Cash Flow}_{i,s,t-1}$	no	no	no	no	yes	no	no	no	no	yes	no	no	no	no	yes
Obs.	152,855	152,855	151,820	151,820	151,820	49,521	49,521	48,955	48,955	48,955	103,334	103,334	102,865	102,865	102,865
R^2	0.31	0.32	0.35	0.35	0.35	0.31	0.32	0.36	0.36	0.36	0.31	0.32	0.34	0.34	0.34
Adjusted-R^2	0.13	0.14	0.14	0.14	0.14	0.15	0.16	0.16	0.16	0.16	0.12	0.13	0.13	0.13	0.13
Within-R^2	0.063	0.046	0.045	0.045	0.045	0.065	0.046	0.044	0.044	0.044	0.063	0.046	0.046	0.046	0.046

NOTES: Table 5 reports the results of estimation of equation (5). See the footnote 44 for the details on the tradable and non-tradable sector classification. I/K is the firm's net investment-capital stock ratio. $\text{FX}_{i,s}$ is a predetermined firm-level dummy that equals one for the firms in the top quartile of the FX exposure distribution at any time during three years prior to the year sanctions regime is instituted. Post is a dummy variable that equals one in 2014, which corresponds to the year when the sanctions regime was instituted, and onward. $\Delta\log\text{S}$ is the firm's sales growth. $\log(\text{S}/\text{K})$ is the error correction term. Cash Flow is the firm's cash flow-total assets ratio. Large is a predetermined firm-level dummy variable that equals one for the firms that are ranked in the top quartile of the firm size distribution at any time during three years prior to the year when sanctions regime is instituted. We measure the firm size by the logarithm of the firm's total assets. Heteroskedastic-consistent standard errors clustered at firm level are reported in parentheses.***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Finally, in Column (5), we interact the firm's profitability captured by the cash flow to assets ratio with the post-sanctions dummy. By doing so, we verify that the variables we use to control for the firm's growth opportunities measured by the firm's sales growth and FX exposure risk measured by the firm's FX debt to total assets ratio are not proxies for the effect of profitability measured as the firm's cash flow to assets ratio on the net investment rate during the post-2014 period. However, the effect of higher FX debt exposure on the net investment rate is reduced once we control for the behavior of firms with greater cash flows. This most likely occurs because such firms will tend to be larger and have higher FX debt exposure, with these effects being absorbed by the interaction term between the post-sanctions dummy and the cash flow variable.

5.2 Sanctions and sectoral confounding effects

In this section, we seek to control for other confounding factors that may have affected investment by Russian non-financial firms which differ along a set of sector-specific characteristics. First, firms with strong supply-chain relationships with different sectors of sanctioning economies could witness significant declines in their imported inputs, which could adversely affect their investment behavior. Second, firms that are differentiated in terms of their oil-cost dependence may have reacted differently to the large oil price decline during the sanctions regime.[47]

To control for the effects of these phenomena, we seek to identify their effects by creating novel sector-level proxies. The first proxy 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.[48] Since many of the sanctions instituted against Russia in 2014 had the aim of inhibiting various activities such as drilling for shale and deep water and Arctic oil, we exclude firms in the energy sector which were subject to sectoral sanctions targeting their inputs of high-technology intermediate inputs. The second proxy captures heterogeneity across industries who use oil as intermediate good in production i.e., manufacturing industries; see Lee and Ni (2002)

[47] In a related analysis, Wildnerova and Blöchliger (2020) examine the firm-level factors such as a firm's age, size, sector, ownership and location 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 Ukrainian crisis."

[48] See Section A.2.1 for the details on the construction of this proxy.

or Gogineni (2010).[49] In this case, we exclude highly upstream industries such as the ones who are directly involved in the exploration and production of crude oil because the oil price decline affected the price of their output as well as their input costs. We also exclude highly downstream industries such as those that refine and distribute the finished products, including gasoline and diesel fuel. Next, in order to capture sectoral variation in firms' sanctioned trade linkages or their oil cost dependence, we define a generic dummy variable denote SecDep_s Specifically, we let this dummy variable equal SancTradeLink_s, which is a predetermined sector-level dummy that equals one for the firms operating in the sectors that are ranked in the top quartile of the sanctioned trade linkage distribution at any time during three years prior to the year when sanctions regime is instituted.[50] We also consider a specification in which the sectoral dummy variable is equal to OilCostDep_s, which is a predetermined sector-level dummy variable that equals one for the firms operating in the sectors that are ranked in the top quartile of the oil-cost dependence distribution at any time during three years prior to the year when sanctions regime is instituted.[51]

We then extend the baseline investment equation (4) as

$$\begin{aligned}(\text{I}_{i,s,t}/\text{K}_{i,s,t-1}) &= \beta_1\text{Post}_t \times \text{SecDep}_s \times \Delta\log(\text{S}_{i,s,t-1}) + \beta_2\text{Post}_t \times \Delta\log(\text{S}_{i,s,t-1}) \\ &+ \beta_3\text{Post}_t \times \text{SecDep}_s + \beta_4\text{Post}_t \\ &+ \beta_5\text{SecDep}_s \times \Delta\log(\text{S}_{i,s,t-1}) + \beta_6\text{X}_{i,s,t-1} + \mu_i + \epsilon_{i,s,t}, \end{aligned} \tag{6}$$

where $(\text{I}_{i,s,t}/\text{K}_{i,s,t-1})$ is the investment-capital stock ratio for firm i operating in sector s at date t, $\Delta\log(\text{S}_{i,s,t-1})$ is the firm's sales growth in sector s at time $t-1$, $\text{X}_{i,s,t}$ is a matrix that contains the investment predictors used in the estimation of the baseline investment equation, and the sectoral dummy variable equals SancTradeLink_s or OilCostDep_s depending on the specification that is considered. Since SancTradeLink_s and OilCostDep_s are predetermined sector-level dummy variables, we cannot identify the main (direct) effect of sanctioned trade linkage or oil-cost dependence on firm-level investment, as these are absorbed by firm-fixed effects.

[49]We provide the details on the construction of this proxy in Section A.2.2.

[50]During the sanctions regime, only 6.6 percent of observations changed the level of sanctioned trade linkage measure from weak to strong.

[51]In the years of the sanctions regime only 5.4 percent of observations changed the level of oil-cost dependence measure from low to high.

5.2.1 The role of sanctioned trade linkages

In this section, we seek to control for trade linkages of firms with countries that impose sanctions on intermediate inputs used by Russian firms. 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. 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 due to heightened uncertainty during the sanctions regime. Further, these effects may also interact with the wait-and-see behavior of investment under uncertainty. Studies such as Ahn and Ludema (2020) have examined the role of input dependence for the activities of Russian firms targeted by sanctions directly. In our empirical analysis, we seek to examine the *indirect* effects of such sanctions on the non-energy producing sector in Russia.

Columns (1)–(5) in Panel A of Table 6 present the results for the sample of Russian non-financial firms after excluding the sub-sample of firms that operate in the energy-producing sector. In line with our a priori view, Columns (1)–(2) show that the coefficient β_3 in equation (5) is estimated to be negative and statistically significant, suggesting that during the sanctions regime the net investment rate of firms operating in sectors that had strong trade linkages with sanctioning countries is at least 5 percentage points lower than that of those operating in sectors that had weaker linkages. In Column (3), we account for the systematic differences between large and small firms in terms of the strength of their trade linkages with sanctioning countries by including Large-year fixed effects. The results regarding the negative effect of having high trade linkages with sanctioning countries continue to hold.

Next, we include 4-digit sector-year fixed effects to control for any supply and demand shocks that might be common to all firms operating in the same 4-digit sectors in Columns (4)–(5). By construction, these sector-year fixed effects control for a potential impact of a negative sector-level supply shock such as the sanctions imposed on the trade of intermediate goods by firms operating in certain Russian sectors. Therefore, the interaction variable i.e., $\text{Post}_t \times \text{SancTradeLink}_s$ constructed to control for this effect is absorbed by the 4-digit sector-year fixed effects. Columns (1)-(5) show that the targeted trade sanctions do not have a significant effect in reducing the response of investment expenditures to demand shocks during the sanctions regime as the coefficient β_1 is estimated to be positive but statistically insignificant. Hence, we do not find evidence for the negative effect of the wait-and-see motive interacted with the sectoral measure of sanctioned trade linkages on investment behavior.[52] Finally, in Column (5), we add the $\text{Post}_t \times \text{Cash Flow}_{i,s,t}$ variable. As in Section 5.1, the results are not affected by this addition, verifying that the firm's sales growth and the sanctioned trade linkages measure do not proxy for the impact of firm's profitability on the net investment rate during the post-2014 period.

5.2.2 The role of oil-cost dependence

The uncertainty associated with the sanctions regime instituted in 2014 was accompanied by a large decline in oil prices. The oil price uncertainty due to such a decline in the price of oil during the sanctions period may be viewed as another important source of uncertainty for the Russian economy. The standard literature on oil price shocks have treated them as supply shocks to the macroeconomy; see Hamilton (1983). Hamilton (1988) has also argued 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. In subsequent work, researchers have differentiated the cost- and demand-dependence of industries to oil shocks; see Lee and Ni (2002) or Gogineni (2010). Yoon and Ratti (2011) further study the effects of energy price uncertainty in an error correction model of investment for U.S. manufacturing firms and find that increases in the conditional variance of energy prices reduces the response to investment to sales growth. In our analysis, to the extent that changes in the oil price create heterogeneity across different industries, we may control for their effect through sector-level variation in their cost dependence on oil.

Columns (1)–(5) in Panel B of Table 6 present the results for the sample of Russian non-financial firms after excluding the sub-sample of firms that operate in the energy-producing sector. These

[52] The reason for may be that there is some time-varying firm-level unobserved heterogeneity that can account for such behavior which is not captured by this proxy that is defined at this sector level.

results show that the coefficient β_3 in equation (6) is estimated to be positive and statistically significant in Columns (1)–(2), suggesting that the decline in oil prices mitigated the negative impact of uncertainty associated with the sanctions regime. Specifically, according to Column (2) in which we include year fixed effects to account for aggregate demand effects associated with the oil price decline, the net investment rate of firms operating in high oil-cost dependent sectors is 1.46 percentage points higher as compared firms operating in the sectors with lower oil-cost dependence in production. In Column (3), we capture systematic differences between large and small firms in terms of their oil-cost dependence in production by adding Large-year fixed effects. This allows us to control for the fact observed in our sample that on average large firms operate in high oil cost-dependent sectors, preventing it from driving our results. The results regarding the positive mitigating effect on investment of firms operating in sectors with high oil-cost dependence continue to hold.

In Columns (4)–(5), we further include 4-digit sector-year fixed effects. These control for any potential demand-side effects of oil price decline after 2014 in addition to supply shocks, which we capture by adding $\text{Post}_t \times \text{OilCostDep}_s$ in Columns (1)–(3). Therefore, the interaction variable i.e., $\text{Post}_t \times \text{OilCostDep}_s$, is absorbed by these sector-year fixed effects. To further interpret the results in Columns (1)–(3), we note that the coefficient β_5 in equation (6) showing the responsiveness of investment to positive demand shocks during the pre-2014 period is estimated to be negative and statistically significant for firms operating in sectors with high oil-cost dependence. This may have to do with the fact that high oil-cost dependence in production imparts a fragility such that firms in these sectors do not respond to future growth opportunities as strongly as firms in the remaining sectors do. On the other hand, the coefficient β_1 in equation (6) is estimated to be positive and statistically significant in Columns (1)–(5). This is an interesting finding that warrants further discussion in that firms operating in high oil-cost dependent sectors appear to reduce their responsiveness less to demand shocks during the sanctions regime than firms operating in low oil-cost dependent sectors. This may have to do with some unobserved characteristics that are common to those firms operating in high oil-cost dependent sectors such as manufacturing and service sectors, as illustrated in Table A.3. Lastly, in Column (5), we add the $\text{Post}_t \times \text{Cash Flow}_{i,s,t}$ variable. As before, the results are robust, suggesting that the firm's sales growth and the oil cost-dependence measure do not proxy for the impact of firm's profitability on the net investment rate during the post-2014.

Table 6: The Role of Sanctioned Trade Linkages and Oil-Cost Dependence

Dependent variable: $I_{i,s,t}/K_{i,s,t-1}$

	Panel A: Sanctioned Trade Linkage					Panel B: Oil Cost Dependence				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
$Post_t \times SancTradeLink_s \times \Delta \log(S_{i,s,t-1})$	0.01244	0.01100	0.01097	0.00607	0.00626					
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)					
$Post_t \times SancTradeLink_s$	-0.05278***	-0.05553***	-0.05152***							
	(0.006)	(0.006)	(0.006)							
$SancTradeLink_s \times \Delta \log(S_{i,s,t-1})$	-0.00930	-0.00782	-0.00760	-0.00651	-0.00658					
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)					
$Post_t \times CostOilDep_s \times \Delta \log(S_{i,s,t-1})$						0.02078**	0.01959**	0.02104**	0.02572**	0.02525**
						(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
$Post_t \times CostOilDep_s$						0.01711**	0.01455**	0.02116***		
						(0.005)	(0.005)	(0.006)		
$CostOilDep_s \times \Delta \log(S_{i,s,t-1})$						-0.01545**	-0.01507**	-0.01581**	-0.01644**	-0.01635**
						(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
$Post_t \times \Delta \log(S_{i,s,t-1})$	-0.03471***	-0.03379***	-0.03339***	-0.03404***	-0.03631***	-0.03429***	-0.03351***	-0.03357***	-0.03765***	-0.03970***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
$Post_t$	-0.09832***					-0.11669***				
	(0.003)					(0.003)				
$\Delta \log(S_{i,s,t-1})$	0.10111***	0.09962***	0.09860***	0.09628***	0.09724***	0.10134***	0.10031***	0.09941***	0.09755***	0.09845***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
$(\Delta \log(S_{i,s,t-1}))^2$	0.03026***	0.02926***	0.02936***	0.02917***	0.02929***	0.03021***	0.02927***	0.02934***	0.02924***	0.02936***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
$\log(S_{i,t-2}/K_{i,t-2})$	0.08509***	0.08490***	0.08460***	0.08495***	0.08496***	0.08520***	0.08499***	0.08468***	0.08492***	0.08493***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Cash $Flow_{i,s,t-1}$	0.05041***	0.04589***	0.04497***	0.04193***	0.02685**	0.05187***	0.04729***	0.04628***	0.04188***	0.02712**
	(0.009)	(0.009)	(0.009)	(0.009)	(0.012)	(0.009)	(0.009)	(0.009)	(0.009)	(0.012)
Firm FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year FE	no	yes	yes	yes	yes	no	yes	yes	yes	yes
Large-year FE	no	no	yes	yes	yes	no	no	yes	yes	yes
Sector-year FE	no	no	no	yes	yes	no	no	no	yes	yes
$Post_t \times$ Cash $Flow_{i,s,t-1}$	no	no	no	no	yes	no	no	no	no	yes
Obs.	153,744	153,744	153,744	152,736	152736	153,744	153,744	153,744	152,736	152,736
R^2	0.32	0.32	0.32	0.35	0.35	0.32	0.32	.32	0.35	0.35
Adjusted-R^2	0.13	0.14	0.14	0.14	0.14	0.13	0.14	0.14	0.14	0.14
Within-R^2	0.063	0.046	0.045	0.044	0.044	0.062	0.045	0.045	0.044	0.044

NOTES: Table 6 reports the results of estimation of the equation (6). I/K is the firm's net investment-capital stock ratio. $SancTradeLink_s$ is a predetermined dummy variable that equals one for the firms operating in the sectors that are ranked in the top quartile of the sanctioned trade linkage distribution at any time during three years prior to the year when sanctions regime was instituted. $OilCostDep_s$ is a predetermined dummy variable that equals one for the firms operating in the sectors that are ranked in the top quartile of the oil-cost dependence distribution at any time during three years prior to the year when sanctions regime is instituted. See Tables 4 –5 for a description of all of the variables. Heteroskedastic-consistent standard errors clustered at firm level are reported in parentheses.***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

5.3 Epilogue: Uncertainty and Investment in Russia

Our goal has been to identify the effects of uncertainty on the behavior of non-financial firms in Russia over the period 2004-2016. As we noted earlier, the Russian economy has been subject to a multitude of confounding factors that led to the environment of heightened uncertainty, especially after 2014. We use the sanctions regime as a quasi-natural experiment to identify the effect of increased uncertainty on investment behavior. In our above analysis, we seek to isolate the impact of phenomena such as exposure to ruble devaluation, the sanctioned trade channel as well as oil-cost dependence in production on the behavior of investment separately.

In this section, we consider an estimation approach that accounts for the effects of these phenomena jointly. The reason is that given the conjuncture in question, these individual phenomena may reflect the effect of common underlying factors and hence, may be correlated with each other. Thus, considering them separately may lead us to attribute a greater than warranted significance to each individual phenomenon. We may view this exercise as better identifying the impact of uncertainty due to sanctions on the investment behaviour of Russian non-financial firms by isolating it from general equilibrium-like effects. This identification requires us to assume that any remaining variation in firm-specific demand and supply conditions during the sanctions regime that are not captured by FX exposure risk, the sanctioned trade channel and oil-cost dependence in production do not vary systematically by the uncertainty prevailing in the Russian economy.

The results in Table 7 show that the post-sanctions period is accompanied by a reduction in investment by Russian non-financial firms even after controlling for the effects of ruble devaluation, the sanctioned trade channel and oil-cost dependence in production that occur simultaneously in a general equilibrium setting. Second, in the line with the predictions of our underlying model, we find that the responsiveness of investment to demand shocks is dampened during the sanctions era. These findings allow us to attribute the negative response of investment to the geopolitical tensions and policy uncertainty that accompanied the imposition of sanctions. Specifically, as shown in Column (2), we observe that for a given sales growth of 1%, the coefficient on Post $\times \Delta \log(S_{i,s,t-1})$ is -0.0385 implies a lower responsiveness of investment to demand shocks of 3.9 percentage points after controlling for the effects of the other confounding factors. This finding remains when we

Table 7: CONTROLLING FOR ALL CONFOUNDING EVENTS

Dependent variable: $I_{i,s,t}/K_{i,s,t-1}$

	(1)	(2)	(3)	(4)	(5)
$Post_t \times FX_{i,s} \times \Delta \log(S_{i,s,t-1})$	-0.00295	-0.00196	-0.00240	-0.00178	-0.00121
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
$Post_t \times FX_{i,s}$	-0.01885**	-0.01913***	-0.01194**	-0.01937**	-0.01802**
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
$Post_t \times SancTradeLink_s \times \Delta \log(S_{i,s,t-1})$	0.01136	0.01051	0.01024	0.00609	0.00632
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
$Post_t \times SancTradeLink_s$	-0.05664***	-0.05815***	-0.05568***		
	(0.006)	(0.006)	(0.006)		
$Post_t \times CostOilDep_s \times \Delta \log(S_{i,s,t-1})$	0.02253**	0.02193**	0.02287**	0.02646**	0.02595**
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
$Post_t \times CostOilDep_s$	0.02750***	0.02619***	0.02925***		
	(0.006)	(0.006)	(0.006)		
$Post_t \times \Delta \log(S_{i,s,t-1})$	-0.03931***	-0.03898***	-0.03849***	-0.03997***	-0.04202***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
$Post_t$	-0.10002***				
	(0.004)				
$FX_{i,s} \times \Delta \log(S_{i,s,t-1})$	0.00333	0.00318	0.00309	0.00400	0.00375
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
$SancTradeLink_s \times \Delta \log(S_{i,s,t-1})$	-0.00885	-0.00776	-0.00755	-0.00680	-0.00691
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
$CostOilDep_s \times \Delta \log(S_{i,s,t-1})$	-0.01627**	-0.01636**	-0.01678**	-0.01802**	-0.01789**
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
$\Delta \log(S_{i,s,t-1})$	0.10482***	0.10372***	0.10292***	0.10044***	0.10136***
Firm controls	yes	yes	yes	yes	yes
$Post_t \times Cash\ Flow_{i,s,t-1}$	no	no	no	no	yes
Firm FE	yes	yes	yes	yes	yes
Year FE	no	yes	yes	yes	yes
Size-year FE	no	no	yes	yes	yes
Sector-year FE	no	no	no	yes	yes
Obs.	150,109	150,109	150,109	149,078	149,078
R^2	0.31	0.32	0.32	0.35	0.35
Adjusted-R^2	0.13	0.14	0.14	0.14	0.14
Within-R^2	0.064	0.047	0.047	0.045	0.045

NOTES: Table 7 reports the results of estimation of the error correction model of investment equation with a full set of controls. See Tables 4, 5 and 6 for a description of all of the variables. Heteroskedastic-consistent standard errors clustered at firm level are reported in parentheses.***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

account for systematic differences between large and small firms in terms of strength of their trade linkages with sanctioning countries, their FX exposure risk and oil cost-dependence in production by including Large-year fixed effects in Column (3). Column (4) shows that the responsiveness of investment to demand shocks is reduced by almost 4 percentage points during the sanctions regime when we include 4-digit sector-year fixed effects.

As a final robustness check, we add the $Post_t \times Cash\ Flow_{i,s,t}$ variable to the estimation. As illustrated in Column (5) of Table 7, the above-mentioned findings remain the same, confirming that variables used to measure the firm's growth opportunities, sanctioned trade linkage, and oil cost-dependence in production do not proxy for the impact of the firm's profitability on the net investment rate during the sanctions regime.

6 Conclusion

In this paper, we quantify the impact of uncertainty on investment behaviour for a rich panel of Russian economy that is constructed using the the Ruslana historical product compiled by BvD. This data set is uniquely suited to studying the investment behaviour of Russian non-financial firms which have experienced periods of sunny optimism characterized by robust investment but have also encountered stormy periods characterized by strong disinvestment behavior over the period 2004-2016.

We use the Russian experience after 2014 to provide a novel laboratory for examining the response of investment to uncertainty shocks. In line with the predictions of the underlying error correction investment model, we find significant negative effects of uncertainty on the response of investment to demand shocks due to the sanctions regime after isolating the joint effects of foreign exchange exposure that works through balance sheet channel of the ruble devaluation, and oil-cost dependence in production as well as of the indirect effects of trade linkages with sanctioning countries on the investment rate. In this way, our study is able to identify general equilibrium-like effects by exploiting the heterogeneous response of firms to exchange rate devaluation, sanctioned trade linkages or declines in the price of oil.

The policy conclusions that emerge from our study reflect the impact of the confluence of these events. We view our results as suggesting that spurring further growth in the Russian economy depends, in part, on overcoming the sluggish response of investment by its private non-financial sector to uncertainty shocks. Whether the Russian economy can surmount such challenges depends on a complex set of economic and political factors whose analysis is beyond the scope of this study.

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A Data

A.1 Firm-level Data

As explained in Section 3.1, we use the Russian data downloaded from the Ruslana Historical product provided by BvD. In order 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.[53]

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.[54] Ruslana reports on firms that employ at least one employee, whereas individual enterprises constitute a significant portion of total firms reported by Rosstat.[55] The data on gross value-added reported by Rosstat are from the national accounts and represent the universe of Russian firms.[56] The operating revenue aggregates 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.[57]

The values in the first row of Panel A in Table A.1 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

[53]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.

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

[55]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.

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

[57]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.

economy reasonably well, that is, on average 30% of Russian firms is reported in our data between 2011–2014.

Table A.1: 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 A.1 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 coverage accounted for by firms belonging to each size class.[58] 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.

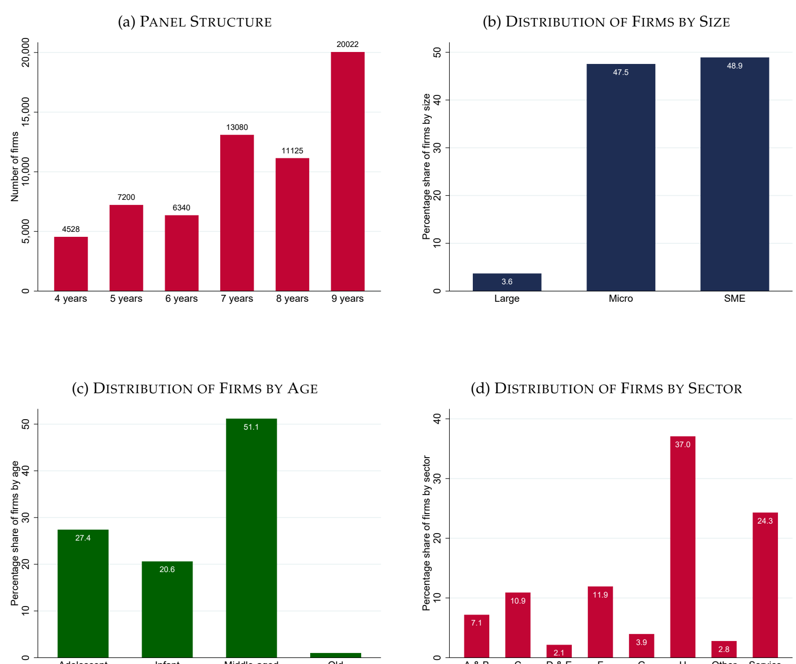
[58]RCSME defines the size categories as follows: micro-sized firm is the one with employment less than 15 and with sales revenue less than 60 million RUR; small-sized firm is the one with 16-101 employees and with sales revenue less than 400 million RUR; medium-sized firm is the one with 101-250 employees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

A.1.1 Descriptive Statistics

In this section, we will begin with the criteria applied to construct the sample we use in the analysis. Then we will provide some descriptive statistics about this sample.

First, we focus on Russian non-financial firms with unconsolidated accounts, dropping those operating in financial sector and in the sectors outside the System of National Accounts (SNA) production boundary.[59] Second, we delete firms with less than three consecutive years' data. Third, in the resulting sample, we keep firms if they are present for at least three years before the sanctions and one year when the sanctions are in place.

Figure A.1: DETAILS ON THE STRUCTURE OF THE SAMPLE OF RUSSIAN NON-FINANCIAL FIRMS



NOTES: Panel (a) illustrates the panel structure of the unbalanced sample we use in our analysis, focusing on 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 A.2 for the corresponding industry definitions of the letters representing different sectors in the bars.

We illustrate the panel structure of this unbalanced sample in Panel (a) of Figure A.1. This figure

[59] BvD provides a detailed sector classification up to four-digit NACE Revision 2 industry classification. We follow this to categorize firms according to sector and drop firms operating in NACE Rev. 2 sectors K, T & U.

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. 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.

Table A.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.

We provide further details on the characteristics of the unbalanced sample we use in our analysis. Panels (b)–(d) of Figure A.1 shows the characteristics of our sample by (i) size, (ii) age and (iii) sector, respectively.[60] We observe that 3.6% of the firms in our sample are considered as "Large" 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,

[60]We follow Eurostat's size categories to label firms in our sample. "Micro" firms are ones with the number of employees less than 10, SMEs with the number of employees between 10 and 249 and "Large" firms have employees that number than greater than 250.

suggesting an adequate coverage of sectors of the Russian economy.

A.2 The Construction of Sector-level Measures using the ICIO Tables

As explained in Section 3.2, we use sector-level data obtained from the ICIO Tables for the period 2005–2015. In the following sub-sections, we provide the details on the construction of the sector-level measures of sanctioned trade linkage and oil-cost dependence that we use in our empirical analysis, respectively.

A.2.1 Sanctioned trade linkage measure

We create a time-invariant sector-level sanctioned trade linkage measure in order to exploit sectoral variation in terms of trade linkages with which Russian non-financial firms operating in different sectors connect to those sanctioning countries. Such a measure may be useful for capturing the observed variation in firms' investment rates after the imposition of sanctions. This measure is constructed as follows. First, for any sector-year combination, we proxy the sanctioned trade linkage with the below measure

$$\text{SancTradeLink}_{s,t} = \sum_{c=1}^{n} \frac{\text{Imported Inputs}_{c,s,t} \times \text{SR}_{c,t}}{\text{Total Imports}_{s,t}}, \tag{7}$$

where $\text{Imported Inputs}_{c,s,t}$ refers to intermediate goods that are bought from the sector s of corresponding country c; $\text{Total Imports}_{s,t}$ refer to total inputs bought from abroad in sector s in the given year t, respectively. $\text{SR}_{c,t}$ 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.[61] Second, for each individual sector, we construct the time average of the sanctioned trade linkage values for the 2005–2013 period.

Note that we construct a time-invariant sector-level sanctioned trade linkage measure using predetermined values prior to the year 2014 when the sanctions on Russia started so that the ranking of sectors in the sanctioned trade linkage distribution does not change with the sanctions regime. This

[61] 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.

allows us to see how an increase in the level of uncertainty associated with this shock affects firm-level investment for firms operating in the sectors with strong and weak sanctioned trade linkages with sanctioning countries ex-ante, respectively.

The sanctioned trade linkage proxy variable that we have constructed measures pre-sanctions sanctioned trade linkage of a given sector s. It captures how strongly a given sector is linked to the sanctioning countries. The third column of Table A.4 presents the time-invariant values of this measure across different sectors. We observe that a consumer goods industry such as "Textiles" has the highest level of sanctioned trade linkage, followed by "Electrical Equipment," "Rubber and Plastic Products," and other manufacturing sectors. These measures reflect the importance of imported consumer and other high-end manufacturing goods for the Russian economy that were subject to sanctions in the period 2014 and onward.

A.2.2 Oil Cost dependence measure

We use a time-invariant sector-level measure in order to control for the differential impact of the oil price decline on the investment behaviour of Russian firms that vary in dependence on oil in their production process. We construct this measure as follows: First, for any sector-year combination, we proxy oil cost dependence with the below measure

$$\text{OilCostDep}_{s,t} = \frac{\text{Oil Input}_{s,t}}{\text{Output}_{s,t}}, \tag{8}$$

where $\text{OilCostDep}_{s,t}$ refers to oil cost dependence of sector s of in the year t; $\text{Oil Input}_{s,t}$ 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.[62] Second, for each individual sector, as we do with the sanctioned trade linkage measure, we construct the time average of the oil cost dependence measures for the 2005–2013 period.

Table A.4 presents the time-invariant values of this measure across different sectors. We observe that the "Coke and Refined Petroleum Products" sector has by far the highest cost dependence on oil, followed by a utilities sector such as "Electricity, Gas, Water Supply, Sewage, Waste and Remediation

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

Table A.3: NON-ENERGY PRODUCING FIRMS WITH HIGH OIL COST-DEPENDENCE

Industry	Number of firms	Percent
Coke and refined petroleum products	418	0.17
Electricity, gas, water supply, sewerage, waste and remediation services	9,671	13.28
Mining and extraction of energy producing products	1293	1.78
Manufacture of basic metals	954	1.31
Chemicals and pharmaceutical products	2,615	3.59
Mining support service activities	814	1.12
Mining and quarrying of non-energy producing products	2,517	3.46
Transportation and storage	16,580	22.76
Other non-metallic mineral products	4,206	5.77
Agriculture, forestry and fishing	28,306	38.86
Rubber and plastic products	2,997	4.11
Paper products and printing	2,467	3.39
Total	70,583	100

Services." Other sectors with high oil cost dependence include manufacturing and mining sectors such as "Mining and Extraction of Energy Producing Products," "Basic Metals," "Chemicals and Pharmaceutical Products," and "Mining Support Service Activities."

Table A.3 illustrates the number of non-energy producing firms operating in the industries with high oil cost dependence. The industries with high oil cost dependence correspond to those that belong to the top quartile of the oil-cost dependence distribution at any time during three years prior to the year when sanctions regime is instituted. In the first column of this table, we rank these selected industries in terms of oil-cost dependence in a descending order. We observe that the largest number of non-energy producing firms with high levels of oil cost dependence include the sectors as"Transportation and storage" or "Electricity, gas, water supply, sewerage" that use oil and other energy products as inputs. Some manufacturing industries that display relatively high measures of oil-cost dependence in their production activities include "Other non-metallic mineral products" and "Chemical and pharmaceutical products."

Table A.4: SANCTIONED TRADE LINKAGE, OIL-COST DEPENDENCE ACROSS INDUSTRIES

OECD ISIC Code	Definition	Sanctioned Trade Linkage	Oil-cost Dependence
01T03	Agriculture, forestry and fishing	0.069	0.342
05T06	Mining and extraction of energy producing products	0.006	2.111
07T08	Mining and quarrying of non-energy producing products	0.054	0.912
09	Mining support service activities	0.019	1.475
10T12	Food products, beverages and tobacco	0.033	0.121
13T15	Textiles, wearing apparel, leather and related products	1.049	0.109
16	Wood and products of wood and cork	0.073	0.194
17T18	Paper products and printing	0.183	0.337
19	Coke and refined petroleum products	0.049	19.209
20T21	Chemicals and pharmaceutical products	0.152	1.586
22	Rubber and plastic products	0.357	0.387
23	Other non-metallic mineral products	0.103	0.887
24	Basic metals	0.123	1.780
25	Fabricated metal products	0.207	0.131
26	Computer, electronic and optical products	0.046	0.081
27	Electrical equipment	0.382	0.116
28	Machinery and equipment, nec	0.225	0.156
29	Motor vehicles, trailers and semi-trailers	0.252	0.128
30	Other transport equipment	0.026	0.137
31T33	Other manufacturing; repair and installation of mach. and equip.	0.251	0.195
35T39	Electricity, gas, water supply, sewerage, waste and remediation services	0.039	5.625
41T43	Construction	0.145	0.242
45T47	Wholesale and retail trade; repair of motor vehicles	0.033	0.175
49T53	Transportation and storage	0.084	0.870
55T56	Accommodation and food services	0.070	0.146
58T60	Publishing, audiovisual and broadcasting activities	0.036	0.112
61	Telecommunications	0.013	0.081
62T63	IT and other information services	0.016	0.105
64T66	Financial and insurance activities	0.041	0.071
68	Real estate activities	0.019	0.073
69T82	Other business sector services	0.026	0.154
84	Public admin. and defence; compulsory social security	0.012	0.225
85	Education	0.021	0.129
86T88	Human health and social work	0.115	0.133
90T96	Arts, entertainment, recreation and other service activities	0.054	0.215

NOTES: In this table, we present the measures of sanctioned trade linkage and cost-side dependence in a given industry. The industries are categorized based on the OECD ISIC Codes. All values are reported in percentage terms. See Sections A.2.1–A.2.2 for details on the construction of these sector-level measures.