IRREVERSIBLE INVESTMENT AND POLITICAL RISK: A CASE STUDY OF RUSSIAN INVESTMENT

by

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A thesis submitted to the

Graduate School of Social Sciences and Humanities

in partial fulfillment for the

degree of

Master of Arts

in

Economics

October 2016

Department of Economics

Koç University

Acknowledgement

I would like to show my gratitude to all those who gave me the possibility to complete this thesis. I am deeply indebted to my supervisor Prof. Sumru Altuğ for the great academic help, guidance and endless support she has given me while doing my thesis. I would like to thank Prof. Izak Atiyas and Prof. Sevcan Yeşiltaş for being members of my thesis committee and spending their valuable time.

It is a pleasure to thank my family for always supporting me throughout my life.

I specifically thank Cemre Onaylı for her detailed comments on my thesis.

I would like to thank my colleagues with whom I had a great time in the Masters Program.

Abstract

This thesis analyzes the effects of the recent uncertainty caused by the sanctions that were implemented against Russia on the investment behavior of investors in Russia using an irreversible investment model with regime switches. With the period of uncertainty caused by sanctions corresponding to lower TFP and a sharp decline in oil prices, this study approximates the current regime of political risk by using low total factor productivity growth and oil prices as indicators and simulate different scenarios. The study uses periods with lower TFP and lower oil price periods as the "bad regime" and the higher TFP and higher oil prices as the "good regime". The results show that periods with higher probability of switching to or remaining at the bad regime correspond to lower and more volatile investment.

Keywords: Irreversible Investment, Regime Switches, Russian Federation, Russia, Sanctions, Oil Prices

Özet

Bu tez, son dönemde Rusya'ya karşı uygulanan yaptırımların oluşturduğu belirsizliğin Rusya'da yatırım yapması beklenen yatırımcıların davranışlarına etkisini geri döndürülemez yatırım ve rejim değişim modelini kullanarak analiz etmektedir. Yaptırım kaynaklı belirsizlik süreci düşük toplam faktör verimliliği ve düşük petrol fiyatlarına denk gelmekte olduğundan, son dönemdeki politik risk rejimi bu iki değer kullanılarak oluşturulmaktadır. Çalışma, düşük toplam faktör verimliliği ile düşük petrol fiyatlarını gösterge olarak kullanarak farklı senaryoların simülasyonlarını değerlendirmektedir. Sonuçlar kötü rejime geçme veya kötü rejimde kalma olasılıklarının yüksek olduğu durumların daha düşük ve oynak yatırım davranışlarıyla ilintili olduğunu göstermektedir.

Anahtar Kelimeler: Geri Döndürülemez Yatırım, Rejim Değişim Modeli, Rusya Federasyonu, Rusya, Yaptırımlar, Petrol Fiyatları

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1 Introduction

Investment decisions are often related to the stability and potential of the economic environment in which the agents plan to invest. The effects of political risk on investment decisions vary with the type of political risk involved. The phenomenon of sanctions is closely related to varying levels of political factors. The type, effect, and the success or failure of sanctions are related to country-specific details. The channels through which sanctions impact investment decisions is specific to the nature of sanctions and the political environment prior and during the sanctions at the sanctioned country.

What are the effects of simultaneous decline in oil prices and adverse political conditions on investment decisions in an energy producing economy? This question is relevant especially for a country like the Russian Federation, known to have one of the most dependent economies on natural resource exports. Political instability and low oil prices present unique circumstances for investment decisions in Russia.

This study applies irreversible investment model with regime-switches to the case of current Russian investment and analyzes the effects of the sanctions regime and the oil price drop on investment decisions of firms in Russia. The main purpose of this research is to analyze the specific effect of sanctions and the falling oil prices on investment in Russia using an irreversible investment model with regime switches. Furthermore, the study models the effect of declining oil prices that correspond to the period of implementation of sanctions on investment.

This thesis is organized as follows: The following section is a review of the literature on investment models, Section 3 provides a historical perspective of the Russian economy using various resources from the remaining literature, Section 4 is a presentation of the relevant aspects using graphs and figures. Section 5 describes the model and methodology used in this thesis, Section 6 is a discussion of solutions to the numerical issues faced in the analysis, Section 7 presents the simulation results, and Section 8 is devoted to concluding remarks. The data resources are listed in the appendix.

2 Literature Review

Altuğ, Demers, and Demers (2007) use a regime switching framework to model irreversible investment behavior under political risk. The theoretical framework they provide is relevant to the case of Russia since the subjective probability of regime shifts changes frequently, and investment can be considered irreversible due to risks related to investors' inability to pull their investment out of Russia if they need to do so easily. The situation in Russia involves different aspects for investors' decisions. Despite the impeding effect of the sanctions on exchange rates and increased volatility, some investors are still willing to invest in Russia and will do so as soon as the sanctions disappear, which would mean a shift to a "good regime" as in the framework of Altuğ, Demers and Demers (2007).

The literature on investment response to uncertainty and demand shocks is helpful in understanding what to expect from the effect of the sanctions regime to the investments. Lucas (1990) analyzes the impact of political risk on capital flow from rich to poor countries. Guo et. al. (2005) build an irreversible investment model with regime shifts and use marginal q.

Sampson (1998) evaluates the effect of parameter uncertainty on irreversible investment choices and argues that this explains decreases in investment associated with unknown expected growth rates. The framework in Sampson (1998) is relevant for changes that result from both oil price shocks and system changes.

Bloom et al. (2006) show that higher uncertainty with partial irreversibility reduces the responsiveness of investment to demand shocks. They use the standard deviation of stock returns to account for uncertainty in the system. Pavlova and Rigobon (2007) evaluate the effect of demand shocks on asset prices and determine that the shocks have a divergence effect on different markets and that the asset prices abroad move in the opposite direction to that of domestic stock and bond markets.

Fatas and Metrick (1995) bring an approach of aggregate demand externality into an irreversible investment model. Their approach is based on strategic interaction among firms that choose a level of irreversibility at the beginning. In their mechanism, uncertainty leads to suboptimal recessions, which leads to inefficient outcomes. Levine et al. (2016) provides a framework for the role of uncertainty in investment specifically for Russia's regions.

Pattillo (1998) looks at the implications of irreversible investment models on the manufacturing investments in Ghana, composing several factors of risks for the Ghanaian case.

Since the sanctions applied against Russia and the almost simultaneous oil price drop that followed account for the period of last two years, there is not a wide range of literature that specifically analyzes the situation in Russia.[1]

The literature that analyzes sanctions has a tendency to focus on either security matters or effectiveness of sanctions on the unwanted policies of the sanctioned country. For instance, Oxenstierna and Olsson (2015) reports mostly from a security perspective on the implications of Russian sanctions. Zamaraev et al. (2014) provides an analysis of the slowdown of Russian economic growth before sanctions were implemented while Zaynutdinov (2015) focuses on the implications of sanctions on energy development.

Dreger et al. (2015), one of the first studies in the field of economics that analyzes the Russian exchange rate changes during sanctions using a variety of time series techniques based on vector autoregression (VAR). They reach the conclusion that the change in exchange rates is more strongly related to the change in oil prices in mid-2014 rather than sanctions and conclude that sanctions affect the volatility of other variables they include. Dreger et al. (2015) use a count index to assess the impact of sanctions in relation to oil prices because of the psychological effects that the media has on consumers and investors, which in some cases cause temporary deviations from what is implied by economic fundamentals. Tuzova and Qayum (2016) apply VAR to quantify the effects of oil price shocks and sanctions on

[1] Kaempfer and Lowenberg (2003) is a work on international sanctions using a perspective of public choice.

economic variables of the Russian economy (namely real GDP, exchange rate,, consumption and fiscal expenditures, and external trade) using quarterly data and reach the conclusion that oil prices significantly impact the Russian economy. Due to the relevance of the oil prices to our problem, we included in the model as an indicator of the unfavorable regime.

The sanctions regime that arose in Russia is subject to changes due to political events. In light of the relevant literature and with consideration of diverse aspects that are relevant to our question, the estimation of probabilities of switching from one regime to the other will be discussed further under Section 5.[2]

3 A historical perspective

The current sanctions regime is the most recent political risk challenge for the contemporary Russian economy, which has experienced more than a few periods of turmoil and uncertainty. Before presenting the theoretical framework and simulations, I provide a brief perspective on the last 25 years of the Russian economy.

3.1 The "Shock Therapy" Years and the 1998 Crisis

Following the collapse of the Soviet Union, there was a lack of an institutional framework that kept foreign investors hesitant to invest in Russia due to partial irreversibility. The transition of the Russian economy in the early '90s laid the groundwork for initial and future investment environment. The transformation has been political as much as it has been economical.

Furthermore, despite being a newly opened economy with vast areas of investment potential, there was an increase in capital flight from Russia, some of which is attributed to the unstable conditions caused by the transition and the almost

[2]World Bank (2016a), World Bank (2016b), World Bank (2015a), World Bank (2015b) and Hansl (2014) provide an overall view on the investment environment and the phase of the Russian economy post-sanctions

exigent need to establish institutions to stimulate the economy.[3] Such institutional stability was essential especially in the oil industry. Due to the long-term nature of oil projects, the changing nature of the taxation and judicial measures created uncertainties that have led to an irreversibility constraint for potential foreign investors in the industry. Despite the vast oil reserves and low cost production opportunities, foreign partnerships or investment has been at low levels for the first half of the decade.

Following the chaotic years of its transition in the early '90s, the oil price drop after the Asian financial crisis put Russia's already vulnerable economy that was–despite the relatively more positive outlook towards the end of 1996– struggling with weak fundamentals in jeopardy. Under these conditions, the extensive borrowing by the Russian government to cover its fiscal deficit (Rutland, 2013) led to the "Russian Crisis of 1998". Theodore and Hout (2013), Sarialioğlu Hayali (2015) provide detailed analyses of the shock therapy years and the implications of the transition experiences on the crisis of 1998 while Watson (1996) provides details on the experiences of the foreign investments in the Russian oil industry.

Towards 1995, some constitutional work has been accomplished towards a safer environment for investors, but the investment environment has not achieved a completely stable level. Decision-making processes were not as fast as they needed to be in order to prevent the Russian crisis in 1998, which corresponds to a sharp decline in productivity and wages.

3.2 Russia in the 2000s

The 2000s witnessed better economic conditions and investment environment for Russia, with a peak in 2012. Between 1999 and 2008, the Russian GDP was growing at rates between 7 and 8 percent, which is regarded to be "almost entirely a by-product of the explosion in the price of oil from $ 10 a barrel in 1998 to $ 147

[3] Loungani and Mauro (2000) argue that "uncertainty over policies, the confiscatory nature of the tax system, the banking system's weakness, and the unusual power of vested interests related to energy sector" were some of the root causes of capital flight in Russia.

a barrel in mid-2008" by Goldman (2009) and many others.

In 2003, regardless of growing perceptions of the risks involved with investing in Russia, the increase in commodity prices did not hold some investors outside of Russia. With the potential profits that the increasing commodity prices implied, from 2003 to 2007, foreign investment in Russia reached its highest levels perhaps in the whole history of Russia.[4]

Then in 2008, investment in Russia faced challenges in diverse dimensions. Aleksashenko (2009) relates the Russian crisis of 2008 to factors related to possible credit crunch, the drop in oil prices, and the overload of short-term foreign loans that could not be refinanced. Additionally, the war between Russian and Georgian troops created a panic amongst investors. After 8 years of relative improvement, economic and political factors led to uncertainty, impacting subjective probabilities in relation to investment in Russia as well.

3.3 The Sanctions

In the fall of 2013, Ukraine was about to sign a trade agreement with the European Union (E.U.). The decision of Yanukovich to not sign the agreement led to protests throughout the country and demonstrations against the government. The events escalated quickly, leading to disputes in Western and Russian perspectives.

The referendum in Crimea (March 2014) corresponds to the beginning of the implementation of U.S.-led sanctions on Russia. Over the summer of 2014, Russia imposed counter-sanctions with a ban on food imports from Western countries. After the Malaysian Airlines plane crash incident (MH17 flight), the U.S. and the EU announced further sanctions on Russia. In February 2015, the Minsk II agreement was signed and the sanctions targeted individuals that caused unrest in Donets and Luhansk.

The sanction regime started in 2014 due to the political tensions between Russia

[4] For a detailed discussion, see Goldman (2009).

and the West over Ukraine, and many countries that have implemented sanctions against Russia decided to expand sanctions further. Under the sanctions regime, which was implemented after the illegal annexation of Crimea and gradually intensified, the uncertainty due to political risks for investors inclined.

The dates on which the intensity of sanctions changed have importance for the study of investment pattern throughout these sanctions. Russia has a unique situation. The sanctions have just started and Russia is far more developed to be considered in a framework of capital flows from poor to rich countries. The political instability, or the “bad regime" arose not from pure unrest inside the country, but instead from several international dynamics, some of which relate to Russia’s domestic issues as well.

Political tensions between Russian Federation and the West were present before, throughout, and after the period of turmoil in Ukraine. Following the illegal annexation of Crimea, The United States (US) and the European Union (E.U.) led implementation of sanctions against Russia, which took the tensions already present in Russian-Western relations to a higher level. Following the crash of Malaysia Airlines Flight 17 (MH17) plane on July 2014, many countries intensified the level of sanctions. Following the sanctions, there was a sharp decline in Russian exchange rates. The decline of oil prices that started in mid-2014, around the same time as the first round of sanctions made the situation even worse for the Russian economy. Russia’s economy has been criticized for its excessive dependence on the energy sector.

The tension between the West and Russia has been present for more than a couple months before sanctions were implemented. The Russian law on gay rights, corruption in the Sochi Winter Olympics organization, Putin’s support for Bashar Al-Assad in the Syrian crisis are a few examples that created a general international dislike, which was reflected in the media for about a year. Russia’s involvement in Ukraine’s issues regarding its position about the E.U., which led to Putin’s sudden annexation of Crimea accelerated the international disapprobation and brought the question of implementing economic sanctions against Russia. Russia remained indifferent to the political requests of the West to stop interfering in Ukraine. Its annexation of Crimea by a referendum is recognized as illegal by the U.S., the E.U., and General Assembly of the United Nations.

The aftermath of November 24, 2015, which led to a 7-month break in Russian-Turkish relations is an independent aspect of sanctions in regards to the Russian-Western sanctions regime. Despite all the disagreements that the two countries faced regarding regional political matters (which includes Turkey's non-recognition of the illegal annexation of Crimea), there were no economic sanctions between them up until the incident of downing of the Su-24 jet on the Syrian border on November 24, 2015. Following the downing of the jet, Russia immediately sanctioned Turkish agricultural goods. The Turkish side adopted a composed attitude for the period that followed.

After 7 months of discontinuity in Turkish-Russian relations, the two countries launched a normalization process and re-vitalized bilateral dialogue. In addition to the lifting of the economic restrictions and amelioration of the political dialogue, the implementation of the energy projects (Turkish Stream and the Akkuyu Nuclear Plant) are being discussed. Dialogue mechanisms on regional crises (namely, Syria and the fight against terrorism, which remain outside the coverage of this thesis) are being built. What is to come out of Russian-Turkish cooperation and the repairing of ties in economics and energy fields will be clear in the following months. For further studies, it might be possible to look at the short-period bilateral sanctions as a case study to look at probabilities after the sanctions are lifted.

This thesis provides an application of the irreversible investment model with Markov regime switches framework to the cases of uncertainty arising from conditions that led to sanctions. It is a challenge to determine the probability at which Russia will return to the "good regime", which is the case for investors before sanctions were imposed for the theoretical analysis purposes of this thesis.

4 Graphs and Figures

4.1 Sanction Indices

In this section I provide a concise description of the timeline of sanctions and provide two graphs of the sanctions implemented against and by Russia. Dreger et al. (2015) created a cumulative composite sanctions index for sanctions implemented by the West against Russia, and by Russia against the West.

Although the sanction indices provide a summary of the properties of sanctions imposed against Russia, this study uses oil prices and TFP growth rates to describe the regimes. Since we did not observe a situation with sanctions having been lifted off yet, it was not possible to set up a model on the determinants of sanctions and estimate the regimes. Since oil price decline corresponds to the same period of sanctions and is closely linked to political variables, we set up our model using oil prices and TFP as determinants of political risk. If we were to use sanctions data in our simulations, we would have assumed that there is no return from the sanctions regime, which would prevent us from allowing for a regime switch from "bad" to "good" states. The use of oil prices and TFP values are detailed further in Section 6.

Fluctuations of oil prices are prone to have political implications and get affected by political variables. For instance, the removal of the sanctions against Iran in January 2016 lead to a further decline in oil prices due to increased supply with the entry of Iran into the global oil market, leading to discussions of the adverse affects it implies for Russia. Hence, the changes in economic variables that impact oil prices are often associated with changes and uncertainties in the political environment[5]. Therefore, we use low oil prices as a determinant of the bad regime.

The Russian sanctions figure shows that the intensity of sanctions implemented

[5]See the discussion on"FOCUS: Russia braces itself for lower oil prices and falling exports as Iran is released from sanctions" published in *Oil and Energy Trends* Vol.41,No.:2,pp:3-6 by Blackwell Publishing Ltd.

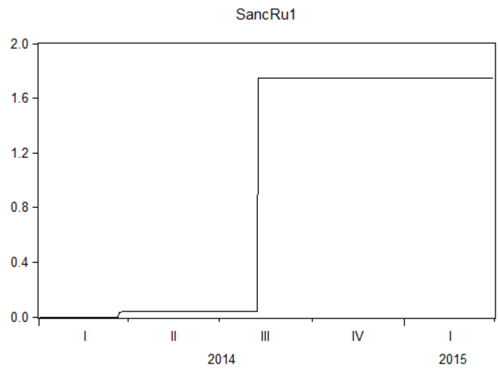

Figure 1: Composite sanctions index (implemented by Russia against the West)

by Russia reaches a peak in the last quarter of 2014 and remains there afterwards. The composite sanctions indices in the two figures are cumulative, therefore the figure shows that Russia implemented the strongest sanctions against the West until the end of 2014.

The sanctions against Russia, however, increase incrementally in various periods. This is perhaps due to the number and variety of countries that decided to implement sanctions against Russia. There are periods where the cumulative index remains constant, but new sanctions have been implemented almost every quarter since the beginning of 2014.

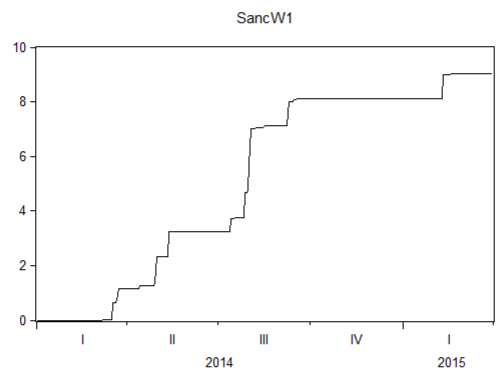

Figure 2: Composite sanctions index implemented against Russia

The sanctions indices discussed in the figures above were taken upon request from Dreger et al (2015) and I provide a concise summary of their calculations.

The index is calculated as a composite index, where there are three types of sanctions. Depending on the weight of the country implementing sanctions against

Russia, they put weights on the sanctions by multiplying the sanction index by the trade share of that country.[6]

The composite sanctions index for sanctions against Russia was calculated as follows by Dreger et al. (2015):

$$S_t^* = \sum_{\tau=1}^{t} \sum_{i=1}^{I} \sum_{j=1}^{J} w_i^* w_j^* s_{\tau ij}^*$$

where $* = RoW, RUS; w_i$ is the weight of sanction i; w_j is the weight of country j; and s_{tij}^* is an indicator function of individual sanction i by/to country j defined as:

$$s_{tij}^* = \begin{cases} 1, & \text{if sanction } i \text{ is in action in period } \tau \\ 0, & \text{otherwise} \end{cases}$$

In order to account for the variety in strength of the sanctions that were implemented at certain times, they assigned the following weights to them:

$$w_i^* = \begin{cases} 1, & \text{if against persons: blocking property/suspension of entry} \\ 2, & \text{if against entities: blocking property/suspension of entry} \\ 3, & \text{if against industries: restricted access to capital market/exports} \end{cases}$$

In order to account for the differences in the effect of a particular sanction imposed by a particular country, Dreger et al. (2015) assigned weights w_j, the trade share of the country j that implemented the sanction attributed to $s_{\tau ij}^*$.

The index on sanctioned stocks appears to have its lowest levels during the post-MH17 flight and the final quarter of 2015, which is two quarters after the composite sanctions index against Russia is at its highest levels.

[6]Further information on their data sources and work can be retrieved at Dreger et al. (2015)

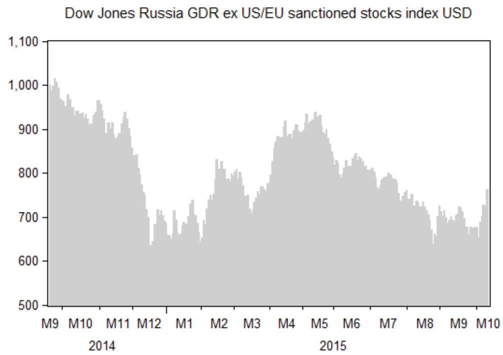

Figure 3: Dow Jones Sanctioned Stocks Index (source: Bloomberg)

4.2 Oil Prices and Russia

Russia is home to the 8th largest oil reserves in the world. It is the largest natural gas supplier for more than a few countries and there are huge resources of coal and minerals. Due to its position as an energy-rich country, energy sector is a substantial part of the Russian economic activity.

The economic literature on the effects of oil prices on the macroeconomy is mostly concerned with the negative effects of an oil price increase (due to political instability in the Middle East, for instance) on oil importing countries. There has not been such negative effects on oil-exporting countries such as Russia. In fact, the increase in oil prices has led to the recovery of Russia from the 1998 crisis. However, what are the implications of an oil price drop on a country with weak fundamentals and reliance on energy imports? The phenomenon of oil is different since it is a natural resource that is attractive to investors of all kinds, but what are the channels through which the political obstacles impact investments under such low prices?

Figure 10 shows the extents of total natural resource rents in the Russian GDP. The maximum share of natural resource rents corresponds to the post-1998 crisis period and the lowest periods correspond to the transition years. However, there is a decline in the years following the global crisis.

The first striking feature of the oil prices figure is the sharp decline in the global financial crisis of 2008. What is next, however, is about the trend component. For

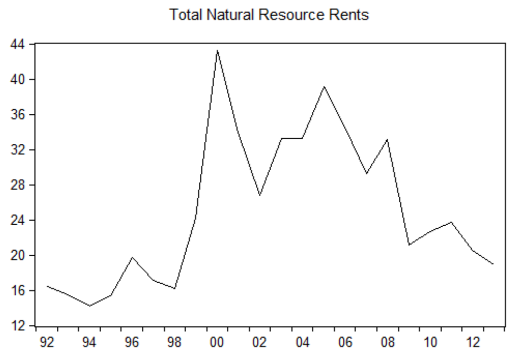

Figure 4: Total Natural Resource Rents of Russian Federation (% GDP) (source: WDI)

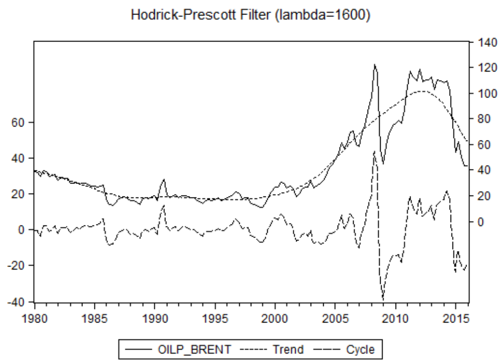

Figure 5: Quarterly Oil Prices 1980-2015 (FRED)

the first time in its past 35-year history, oil prices are not on a cyclical decline. The trend component is on a steep downhill path, too. What does this imply for energy investment in Russia and its recovery if another crisis was to occur? The early 2000s are the years that witnessed oil price increase, which is often attributed to the recovery of Russian economy from the1998 crisis.

This study uses the low oil prices and low TFP growth periods as the “bad regime" in the Markov regime switching framework.

4.3 To invest or not to invest

In this section, we evaluate the investment environment in Russia. Even though this study does not use financial flows data, they nevertheless reflect the level of risk perceived by investors in an economy. Therefore this section describes both financial and capital flows into Russia.

This thesis evaluates the effects of political risk on real investments in Russia. However, the perception of the investment environment sheds light on the way investment evolves.

The perceptions of political risk impact investors' decisions and the effect of media and the analyses done by investment specialists affect how they make decisions. This is one of the key reasons for the relevance of the irreversible investment model with regime switches and learning to analyze the impact of sanctions on Russian investment. Investors update their information on the uncertainty and risk involved in Russia by the political developments and make their decisions.

The political risk calculated by Bloomberg is displayed in the figure below. The numbers show that political risk has been at its highest throughout 2015, and the risk has not been larger than the 2009-2010 values in 2014. As the tensions between the Russia and the rest of the world escalated since the end of 2014, the political risk has reached its peak in the third quarter of 2015.

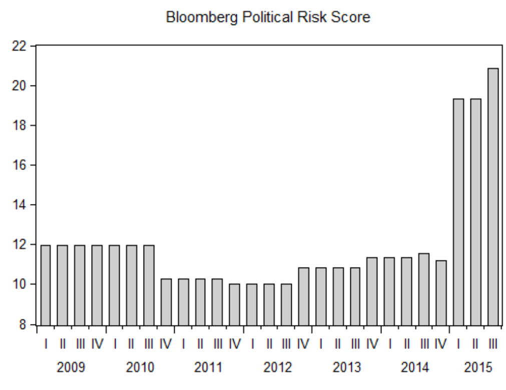

Figure 6: Political Risk Score of Russia (source: Bloomberg)

Another risk measure of risk in Russia is the monthly economic policy uncertainty index. Figure 6 show the trend and cyclical components of the index. The highest periods of the trend correspond to 1994-96 and 2013-2014 and relatively high volatility is observed in these periods. Even though Russia has not certainly been a country with a stable and well-constructed economic policy –perhaps due to its rushed transition after a collapse– the years of recovery from the 1998 crisis reflect to the economic policy uncertainty index as a decreasing trend and smaller fluctuations in the cyclical component.

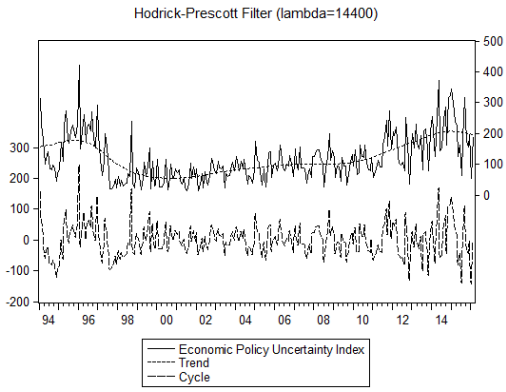

Figure 7: Economic Policy Uncertainty Index (source: FRED)

Despite the increase in the calculated political risk, recent commentary by strategists on whether to invest in Russia does not solely consist of advice to refrain from investing in Russia. According to the media resources, now might even be the best time to invest in Russia. [7] The risks are acknowledged, but some recommend that it might be a good time to invest despite these risks. [8]

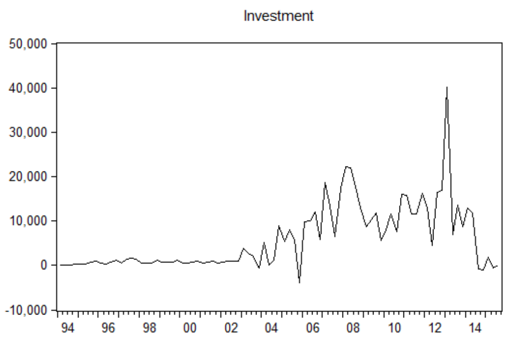

Figure 8: Quarterly Russian Investment 1994-2015 (source: Central Bank of Russia)

[7] See the newspaper article by Holly Ellyatt titled "Russia: Time to invest despite the sanctions threat?" on *CNBC*, June 10, 2015 at `http://www.cnbc.com/2015/06/10/russia-time-to-invest-despite-sanctions-threat.html`

[8] David Stubbs, a global market strategist at J.P. Morgan Asset Management told CNBC in February 2015 (Ranasinghe, Dhara, "This year's best performing stock market is... Russia" in *CNBC*, which can be accessed at `http://www.cnbc.com/2015/02/24/this-years-best-performing-stock-market-isrussia.html` that it might be a good time to invest in Russia but warned about the risks involved. He explained, "So you could put your money into Russian assets and it might be very hard to get your money out." Stubbs' comment on investing in Russia is an example of how subjective probability can affect investment decisions.

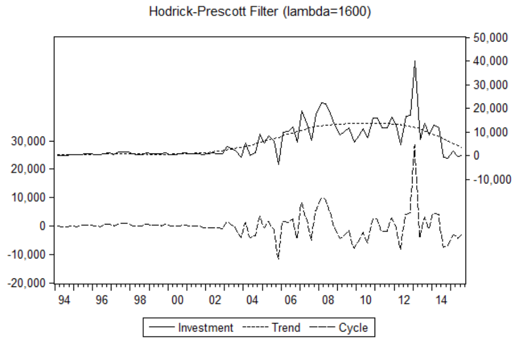

Figure 9: Investment Trend and Cyclical Component

The recovery of Russian economy after the 1998 crisis is reflected in the investment figures with an upward trend starting in early 2000s. In 2012, there is a sharp increase with the improved investment climate, the investment gets better than it has ever been in the past 20 years. Even though the '98 crisis had detrimental impact on real wages and productivity, investment does not seem to have had a major harm from it. After 2014, there is a downward trend, which might take Russia back to similar conditions to the ones before 2000s.

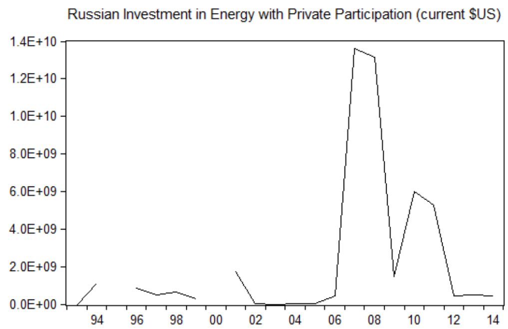

Figure 10: Energy Investment in Russian Federation (source: WDI database)

Even though the data on energy investments with private participation in Russian Federation is not complete, two dates stick out on the figures. First is the years following 2005 and the second is the global 2008 crisis, which corresponds to a sharp decline in oil prices. Because of consistent availability of data on investment the main investment data for the model will be the quarterly Russian investment as taken from Central Bank of Russia (CBR).

The figure above presents the gross capital formation in Russian Federation be-

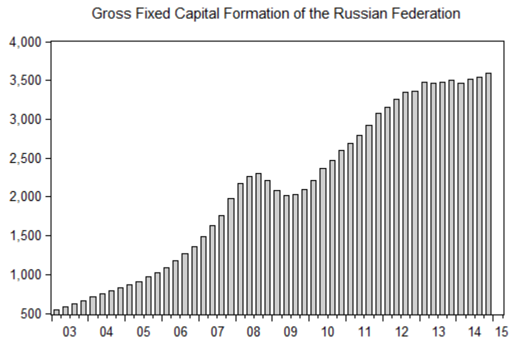

Figure 11: Gross Fixed Capital Formation of the Russian Federation (source: FRED)

tween the first quarter of 2003 and the end of 2014. The beginning of the millennium (with a decrease during the 2008 crisis) consists of the years of increasing capital accumulation and recovery for the Russian economy.

Despite the vast oil reserves and the opening of the economy to the world in the early '90s, investment in the Russian oil and gas sector has remained at adequate levels. The insufficient cash and technology of domestic firms and factors that kept foreign firms from coming into Russia account for the reasons behind such levels of investment.[9] I discuss the place of oil in Russia's economy in the next section.

4.4 Russian Wages and Productivity

The structures of the Russian economy related to wages and productivity will be used in the methodological section. Here I provide an initial look at the figures to provide a deeper understanding. In the figures below, the 1998 crisis is a period of steep declines.[10]

The real wage trend component of Russia has a relatively monotone trend that is neither upward nor downward in 2000s. Even during the 1998 crisis, the sharp decline is mostly engendered in the cyclical component. However, the trend has been tilted slightly downward in recent years, falling at the period of the interest

[9]Watson (1996) evaluates the flawed law-making system and institutions that prevented oil industry investments in detail.

[10]For a study solely focused on labor productivity trends during transition years, see Linz (2000).

of this research.

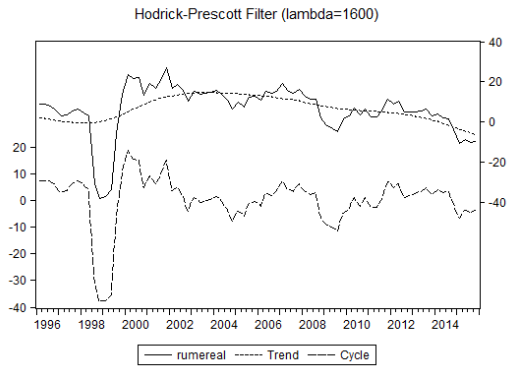

Figure 12: Quarterly Real Wage Series 1996-2014 (Bloomberg)

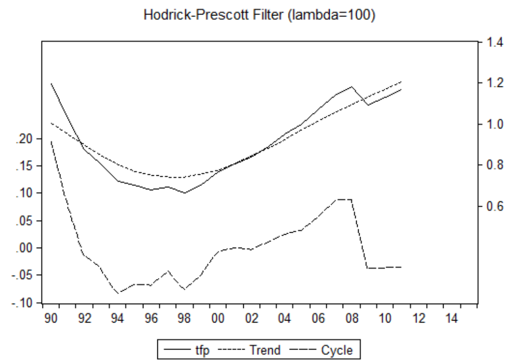

Figure 13: Annual Total Factor Productivity of Russian Federation 1990-2014 (FRED)

The episode of the 1998 Russian crisis is observed on the figures of real wage series and productivity as a sharp decline, and it is deeper for the quarterly real wage series. Despite the cyclical decline in the recent years following the 2008 crisis, an upward TFP trend remains to be in effect.

The data on the refinancing rate of Russian banks (presented in Figure 14) is available from the third quarter of 2013, and the steep increase occurs in the final quarter of 2014, which corresponds to the period after the incident of the MH17 flight.

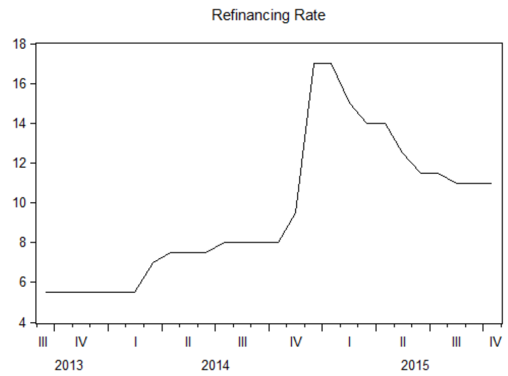

Figure 14: Refinancing rate of Russian banks (source: Bloomberg)

5 Theoretical Framework

We use the irreversible investment model to examine the impact of political risk on firms for Russia. Altug, Demers, and Demers (2007) have studied the role of risk of separation of Quebec from Canada as a form of political risk that may negatively affect irreversible investment decisions. In this thesis, we consider the economic and political sanctions imposed on individuals and various economic entities in the Russian Federation as a form of political risk, and use the model developed by Altug, Demers, and Demers (2007) to quantitatively assess the impact of such political risk.

The capital stock of a firm may be highly firm-specific or industry-specific such as in aeronautics or energy-related industries, and industry level uncertainty may affect all firms similarly. Hence, if firms wish to sell their excess capital in response to an adverse shock, they may not be able to find buyers. Even for less firm- or industry-specific capital goods, there may exist a "lemons" problem of adverse selection in the market for used capital that may similarly prevent firms from disinvesting. In what follows we abstract from resale markets altogether (i.e., we assume complete irreversibility) which allows for a simpler framework. In this setting uncertainty has a particularly important impact on investment.

5.1 The firm's short-run profit function

We consider a monopolistically competitive risk neutral firm which makes variable input and investment decisions each period. At time t it produces output, Y_t, using its beginning-of-period capital stock, K_t, and a variable labor input, L_t. The firm's production function is given by $Y_t = F(K_t, L_t, A_t)$, where A_t is a stochastic technology shock and F is twice continuously differentiable, increasing, concave function and satisfies the Inada conditions. Let p_t denote the stochastic output price. We assume a constant elasticity demand function: $p_t = (\alpha_t)^{-\frac{1}{\varepsilon}}(Q_t)^{\frac{1}{\varepsilon}}$ where $\varepsilon < -1$ is the price elasticity of demand and α_t is a stochastic parameter representing the state of demand.

The firm's production function: $Q_t = F(K_t, L_t, A_t) = A_t K_t^{1-\eta} L_t^{\eta}$, where A_t is a stochastic shock to technology. We **do not** allow for increasing returns to scale, although it is possible to do so. Denoting the wage by w_t, the firm's short-run profit function that gets optimized over the variable factors of production is given by $\Pi_t = p_t Q_t - w_t L_t$. The production function is given by

$$Q_t = A_t K_t^{1-\eta} L_t^{\eta}, \quad 0 < \eta < 1, \tag{1}$$

where A_t is a technology shock. Using these relations, the profit function may be written as:

$$\Pi = \alpha_t^{-\frac{1}{\varepsilon}} \left(A_t K_t^{1-\eta} L_t^{\eta} \right)^{\frac{1+\varepsilon}{\varepsilon}} - w_t L_t = \alpha_t^{-\frac{1}{\varepsilon}} A_t^{\frac{1+\varepsilon}{\varepsilon}} K_t^{\frac{(1-\eta)(1+\varepsilon)}{\varepsilon}} L_t^{\frac{\eta(1+\varepsilon)}{\varepsilon}} - w_t L_t.$$

The first-order conditions with respect to the optimal choice of the labor input are given by:

$$\frac{\partial \Pi}{L_t} = \frac{\eta(1+\varepsilon)}{\varepsilon} \alpha_t^{-\frac{1}{\varepsilon}} A_t^{\frac{1+\varepsilon}{\varepsilon}} K_t^{\frac{(1-\eta)(1+\varepsilon)}{\varepsilon}} L_t^{\frac{\eta(1+\varepsilon)-\varepsilon}{\varepsilon}} - w_t = 0,$$

which can be written as

$$L_t^{\frac{\eta(1+\varepsilon)-\varepsilon}{\varepsilon}} = \frac{\varepsilon}{\eta(1+\varepsilon)} \alpha_t^{\frac{1}{\varepsilon}} A_t^{-\frac{1+\varepsilon}{\varepsilon}} K_t^{-\frac{(1-\eta)(1+\varepsilon)}{\varepsilon}} w_t.$$

Simplifying yields

$$L_t = \left(\frac{\varepsilon}{\eta(1+\varepsilon)}\right)^{\frac{\varepsilon}{\eta(1+\varepsilon)-\varepsilon}} \alpha_t^{\frac{1}{\eta(1+\eta)-\varepsilon}} K_t^{-\frac{(1-\eta)(1+\varepsilon)}{\eta(1+\varepsilon)-\varepsilon}} A_t^{-\frac{1+\varepsilon}{\eta(1+\varepsilon)-\varepsilon}} w_t^{\frac{\varepsilon}{\eta(1+\varepsilon)}}. \tag{2}$$

We can write

$$L_t^{\frac{\eta(1+\varepsilon)}{\varepsilon}} = \left(\frac{\varepsilon}{\eta(1+\varepsilon)}\right)^{\frac{\eta(1+\varepsilon)}{\eta(1+\varepsilon)-\varepsilon}} \alpha_t^{\frac{\eta(1+\varepsilon)}{\varepsilon(\eta(1+\varepsilon)-\varepsilon)}} K_t^{-\frac{(1-\eta)\eta(1+\varepsilon)^2}{\varepsilon(\eta(1+\varepsilon)-\varepsilon}} A_t^{-\frac{\eta(1+\varepsilon)^2}{\varepsilon(\eta(1+\varepsilon)-\varepsilon)}} w_t^{\frac{\eta(1+\varepsilon)}{\eta(1+\varepsilon)-\varepsilon}}.$$

Substituting L_t and $L_t^{\frac{\eta(1+\varepsilon)}{\varepsilon}}$ in the expression for the firm's short-run revenues and costs yields

$$\begin{aligned}
p_tQ_t &= \alpha_t^{-\frac{1}{\varepsilon}} A_t^{\frac{1+\varepsilon}{\varepsilon}} K_t^{\frac{(1-\eta)(1+\varepsilon)}{\varepsilon}} L_t^{\frac{\eta(1+\varepsilon)}{\varepsilon}} \\
&= \left(\frac{\varepsilon}{\eta(1+\varepsilon)}\right)^{\frac{\eta(1+\varepsilon)}{\eta(1+\varepsilon)-\varepsilon}} \alpha_t^{-\frac{1}{\varepsilon}} A_t^{\frac{1+\varepsilon}{\varepsilon}} K_t^{\frac{(1-\eta)(1+\varepsilon)}{\varepsilon}} \alpha_t^{\frac{\eta(1+\varepsilon)}{\varepsilon(\eta(1+\varepsilon)-\varepsilon)}} K_t^{-\frac{\eta(1-\eta)(1+\varepsilon)^2}{\varepsilon(\eta(1+\varepsilon)-\varepsilon)}} A_t^{-\frac{\eta(1+\varepsilon)^2}{\varepsilon(\eta(1+\varepsilon)-\varepsilon)}} w_t^{\frac{\eta(1+\varepsilon)}{\eta(1+\varepsilon)-\varepsilon}} \\
&= \left(\frac{\varepsilon}{\eta(1+\varepsilon)}\right)^{\frac{\eta(1+\varepsilon)}{\eta(1+\varepsilon)-\varepsilon}} \alpha_t^{\frac{1}{\eta(1+\varepsilon)-\varepsilon}} A_t^{-\frac{1+\varepsilon}{\eta(1+\varepsilon)-\varepsilon}} K_t^{-\frac{(1-\eta)(1+\varepsilon)}{\eta(1+\varepsilon)-\varepsilon}} w_t^{\frac{\eta(1+\varepsilon)}{\eta(1+\varepsilon)-\varepsilon}}.
\end{aligned}$$

and

$$\begin{aligned}
w_tL_t &= \left(\frac{\varepsilon}{\eta(1+\varepsilon)}\right)^{\frac{\varepsilon}{\eta(1+\varepsilon)-\varepsilon}} w_t^{\frac{\varepsilon+\eta(1+\varepsilon)-\varepsilon}{\eta(1+\varepsilon)-\varepsilon}} \alpha_t^{\frac{1}{\eta(1+\varepsilon)-\varepsilon}} K_t^{-\frac{(1-\eta)(1+\varepsilon)}{\eta(1+\varepsilon)-\varepsilon}} A_t^{-\frac{1+\varepsilon}{\eta(1+\varepsilon)-\varepsilon}} \\
&= \left(\frac{\varepsilon}{\eta(1+\varepsilon)}\right)^{\frac{\varepsilon}{\eta(1+\varepsilon)-\varepsilon}} w_t^{\frac{\eta(1+\varepsilon)}{\eta(1+\varepsilon)-\varepsilon}} \alpha_t^{\frac{1}{\eta(1+\varepsilon)-\varepsilon}} K_t^{-\frac{(1-\eta)(1+\varepsilon)}{\eta(1+\varepsilon)-\varepsilon}} A_t^{-\frac{1+\varepsilon}{\eta(1+\varepsilon)-\varepsilon}}.
\end{aligned}$$

Hence, the firm's short-run profit function that gets optimized over the variable factors of production can be expressed as follows:

$$\begin{aligned}
\Pi = p_tQ_t - w_tL_t &= \left(\frac{\varepsilon}{\eta(1+\varepsilon)}\right)^{\frac{\eta(1+\varepsilon)}{\eta(1+\varepsilon)-\varepsilon}} \alpha_t^{\frac{1}{\eta(1+\varepsilon)-\varepsilon}} A_t^{-\frac{1+\varepsilon}{\eta(1+\varepsilon)-\varepsilon}} K_t^{-\frac{(1-\eta)(1+\varepsilon)}{\eta(1+\varepsilon)-\varepsilon}} w_t^{\frac{\eta(1+\varepsilon)}{\eta(1+\varepsilon)-\varepsilon}} \\
&\quad - \left(\frac{\varepsilon}{\eta(1+\varepsilon)}\right)^{\frac{\varepsilon}{\eta(1+\varepsilon)-\varepsilon}} \alpha_t^{\frac{1}{\eta(1+\varepsilon)-\varepsilon}} A_t^{-\frac{1+\varepsilon}{\eta(1+\varepsilon)-\varepsilon}} K_t^{-\frac{(1-\eta)(1+\varepsilon)}{\eta(1+\varepsilon)-\varepsilon}} w_t^{\frac{\eta(1+\varepsilon)}{\eta(1+\varepsilon)-\varepsilon}}.
\end{aligned}$$

Thus, the firm's profit function can be expressed as

$$\Pi(K_t, \alpha_t, A_t, w_t) = \upsilon \alpha_t^{\mu_1} K_t^{\mu_2} A_t^{\mu_3} w_t^{\mu_4}, \tag{3}$$

where

$$
\begin{aligned}
\upsilon &= \left(\frac{\varepsilon}{\eta(1+\varepsilon)}\right)^{\frac{\eta(1+\varepsilon)}{\eta(1+\varepsilon)-\varepsilon}} - \left(\frac{\varepsilon}{\eta(1+\varepsilon)}\right)^{\frac{\varepsilon}{\eta(1+\varepsilon)-\varepsilon}}, \\
\mu_1 &= \frac{1}{\eta(1+\varepsilon)-\varepsilon}, \\
\mu_2 &= -\frac{(1-\eta)(1+\varepsilon)}{\eta(1+\varepsilon)-\varepsilon} = 1-\mu_1, \\
\mu_3 &= -\frac{1+\varepsilon}{\eta(1+\varepsilon)-\varepsilon}, \\
\mu_4 &= \frac{\eta(1+\varepsilon)}{\eta(1+\varepsilon)-\varepsilon},
\end{aligned}
$$

such that $\upsilon > 0$, $0 < \mu_1 < 1$, $0 < \mu_3 < 1$ and $\mu_4 < 0$. For future reference, we also note that $\mu_2 = \mu_3 + \mu_4$. With these definitions, notice that Π_t is increasing in K_t, A_t and α_t, decreasing in w_t; strictly concave in K_t, α_t and A_t and bounded for finite K_t, α_t, A_t and w_t.

The firm's after-tax cash flow at time t is $R_t = (1-\tau_t)\Pi(K_t, \alpha_t, A_t, w_t) - p_t^I I_t$, where I_t is the firm's rate of gross investment measured in physical units, and $p_t^I = (1-\gamma_t - z_t)p_t^k$ is the after-tax price of investing, where p_t^k denotes the purchase price of investment goods, z_t is the present value of tax deductions on new investment at date t, and γ_t is the investment tax credit at time t as a percentage of the price of the investment good.

The law of motion for the firm's capital stock is given by $K_{t+1} = (1-\delta)K_t + I_t$, and the irreversibility constraint states that investment must be nonnegative, $I_t \geq 0$.

5.2 Regime Shifts

We now discuss how to introduce political risk into a model of irreversible investment. Political risk affects investment through its impact on the distributions of the state of demand, productivity and the discount factor. Let $\theta_t = r + \varphi_t$ where φ_t denotes the risk premium for the Russian Federation due to political risk.[11]

[11] More generally, we can view the firm as a risky asset with a required rate of return, θ_t where $\theta_t = r + \varphi_t + \pi_t$ where π_t is the equity premium. See, for example, Smith and Wickens (2002), Demers, Demers, and Altug (2003) or Altug and Labadie (2008).

The firm's stochastic discount factor is $\beta_t = (1 + \theta_t)^{-1}$. The state of demand, the state of productivity and the discount factor have different distributions depending on the regime. Suppose that α_t, A_t and θ_t take on values in the sets $\bar{A}$, $\bar{P}$ and $\bar{B}$, respectively, and that they follow first-order Markov processes. That is, letting $h_t \equiv (\alpha_t, A_t, \theta_t)$, $f^{s_t}(h_{t+1}|h_t)$ denotes the conditional density of h_t, given the regime s_t at time t. As we explain below, investors face a less favorable distribution of h in the "bad" regime.

In the model with regime shifts, firms face two regimes, a less favorable regime denoted regime 0, and the regime 1, a transition to which may occur with positive probability. We define regime 1 as the "good" regime for fundamentals such as demand, costs of investment, or risk premium while regime 0 is the "bad" regime in which (a subset of) these quantities may have worse distributions. In our application, we model the "bad" regime as the current sanctions regime with low oil prices facing the Russian Federation and the "good' regime as one without as the sanctions and with higher oil prices.

The regime shifts are governed by a two-state Markov chain with time-varying transition probabilities. Here $\chi_{t,ii} = Pr(s_{t+1} = i|s_t = i, x_t), i = 0, 1$ is the probability of remaining in the current regime at time $t + 1$, and $\chi_{t,ji} = Pr(s_{t+1} = j|s_t = i, x_t), i \neq j, i = 0, 1$ is the probability of a regime switch to regime j in period $t + 1$ given that the regime at time t is i. Here $\mathbf{x_t}$ is a vector of economic and political variables at time t, which firms use to assess the transition to next period's regime.

The condition $\chi_{t,10} > 0$ implies that in a case of policy shift to regime j at some time $s < t$, there is a possibility of returning to the current regime ante at some future date. By contrast, a value of $\chi_{t,10} = 0$ implies that regime 1 is an absorbing state from which no return is possible. In our analysis, we will treat the sanctions regime as a non-absorbing state.

5.3 Optimal Investment Rule

We can express the firm's problem recursively using a dynamic programming approach. The state variables consist of $K_t, h_t, \mathbf{x_t}$, and s_t. The value function of the firm's optimization problem is given by

$$V(K_t, h_t, \mathbf{x}_t, s_t = i) = \max_{I_t}\{(1-\tau)\Pi(K_t, \alpha_t, A_t, w_t) - p_t^I I_t +$$
$$\beta_t \sum_{j=0}^{1} \int_{H\times X} \chi_{ij} V(K_{t+1}, h_{t+1}, \mathbf{x}_{t+1}, s_{t+1} = j) f^{s_t}(h_{t+1}|h_t) f_{\mathbf{x}}(\mathbf{x_{t+1}}|\mathbf{x_t}) d\mathbf{x_{t+1}} dh_{t+1}\} \quad (4)$$

subject to the law of motion for capital $K' = (1-\delta)K + I$, the irreversibility constraint $I \geq 0$, and given K, h, and s.

Let V_k denote the partial derivative of V with respect to K. Hence the first-order necessary and sufficient conditions for the optimization problem at time t are:

$$p_t^I + \beta_t \sum_{j=0}^{1} E_t \chi_{ij} V_K(K_{t+1}, h_{t+1}, \mathbf{x_{t+1}}, s_{t+1} = j) \leq 0 \quad \text{if } I_t^* = 0$$
$$p_t^I + \beta_t \sum_{j=0}^{1} E_t \chi_{ij} V_K(K_{t+1}, \Psi^{t+1,j}(h_{t+1}), \mathbf{x_{t+1}}, s_{t+1} = j) = 0 \quad \text{if } I_t^* > 0,$$

where $E_t(\cdot)$ denotes the expectation over the future state h_{t+1}, conditional on the future regime $s_{t+1} = j$ for $j = 0, 1$. Using the envelope theorem, the shadow value of capital may be expressed as

$$V_K(K_{t+1}, h_{t+1}, \mathbf{x_{t+1}}, s_{t+1} = i) = (1-\tau_{t+1})\Pi_K(K_{t+1}, \alpha_{t+1}, w_{t+1}, A_{t+1}) +$$
$$(1-\delta)\min[p_{t+1}^I, \beta_t \sum_{j=0}^{1} E_{t+1}\chi_{ij} V_K((1-\delta)K_{t+1}, h_{t+2}, \mathbf{x_{t+2}}, s_{t+2} = j)]$$

where Π_K is the partial derivative of Π with respect to K_{t+1}.

The first-order condition for time t can be rearranged after substituting for the shadow price and for $\beta = (1+r)^{-1}$ as

$$(1-\tau_{t+1}) E_t \Pi_K\Big(K_{t+1}, \alpha_{t+1}, A_{t+1}, w_{t+1}\Big) = c_t + \Phi_t, \quad (5)$$

where the expectation $E_t(\cdot)$ also includes the expectation over the regime shift probabilities. In this expression, $c_t = p_t^I(\theta_t + \delta) - (1-\delta)(E_t p_{t+1}^I - p_t^I)$ is the firm's cost of capital as in Jorgenson (1963), and

$$\Phi_t \equiv (1-\delta)\, E_t\{p_{t+1}^I - \min\left[p_{t+1}^I, \beta_{t+1}\sum_{i=0}^{1} E_{t+1}\chi_{ji}V_K\left((1-\delta)\, K_{t+1}, h_{t+2}, \mathbf{x}_{t+2}, s_{t+2}=i\right)\right]\} \quad (6)$$

is a time-varying marginal irreversibility *risk premium* when the firm invests an additional unit.

If we did not allow for irreversibility, the above relation would reduce to

$$(1-\tau_{t+1})E_t\Pi_K\left(K_{t+1}, \alpha_{t+1}, A_{t+1}, w_{t+1}\right) = c_t,$$

In the presence of irreversibility, the second term represents a risk premium for the loss of flexibility that the firm incurs when investment is irreversible. This problem arises from the firm's inability for disinvestment if the state of demand or productivity should turn out to be less favorable than expected. The risk premium plays an analogous role to the marginal adjustment cost in cost of adjustment models of investment, but it is endogenously determined and depends specifically on the uncertainty and risk faced by the firm.

To give content to our assumption that political risk leads to less favorable distributions for α_t, A_t and θ_t, we will assume that α_t, A_t are stochastically smaller and that θ_t is stochastically larger (in the sense of first-order-stochastic dominance, or FSD) in the "bad" regime.[12] As firms now assign a positive probability of facing lower states of demand and productivity and higher interest rates than in the current political regime downside risk increases. Let $\widehat{h}_t \equiv (\widehat{\alpha}_t, \widehat{A}_t, \widehat{\theta}_t)$ be the value of h_t such that it is optimal not to invest at t.[13] Under irreversibility a shift in the distribution in the range $0 < \alpha_{t+1} \leq \widehat{\alpha}_{t+1}$, $0 < A_{t+1} \leq \widehat{A}_{t+1}$ and $0 < \theta_{t+1} \leq \widehat{\theta}_{t+1}$

[12]We may also characterize the "bad" regime as involving more volatile, and hence less favorable, distributions for α_t, A_t and θ_t.

[13]$\widehat{h}_t$ is defined by $p_t^I = \frac{1}{(1+\widehat{\theta}_t)}\int_H V((1-\delta)K_{t+1}, h_{t+1}, \mathbf{x}_{t+1}, s_{t+1}) f^{s_{t+1}}(h_{t+1}|\widehat{h}_{t+1})dh_{t+1}$ where $I_t = 0$.

induced by political risk will affect the decision as to whether to invest or not as well as the amount invested. This is Bernanke's "bad news principle." As the option value of waiting rises the incidence of a binding irreversibility constraint increases: that is, $\widehat{h}_t$ rises. Furthermore, when it invests, the firm invests a lower amount.

5.4 Impact of interest rates

One important impact of political risk even in the "good" regime is through interest rates that rise due to a premium. This is important in the Russian case, as interest rates rose due to the large depreciation in the nominal exchange rate caused by sanctions and the incidence of lower oil prices.

To evaluate theoretically the impact of the increase in interest rates, first assume that θ_t is *i.i.d.* A shift in the distribution of θ_t in the "good" regime will increase the incidence of a binding irreversibility constraint ($\widehat{h}_t$ rises). Furthermore, if an interior solution exists at t, we obtain from the first-order condition

$$\frac{\partial I}{\partial \theta} = \frac{p^I}{E \int V_{KK}(\cdot) f^{s'=j}(h'|h)dh'} < 0, \tag{7}$$

where $E(\cdot)$ is the expectation with respect to the regime shift probabilities. The risk premium leads to higher interest rates that lower investment. This is the cost increasing effect. When θ_t is serially dependent, there is an additional effect of a rise in the current interest rate, namely, the information effect that arises as an increase in θ_t signals a change in future values. Assuming that α A and θ are mutually independent, so that $f^{s'}(h'|h) = f^{\alpha,s'}(\alpha'|\alpha) f^{A,s'}(A'|\alpha) f^{\theta,s'}(\theta'|\theta)$, the total effect is

$$\frac{\partial I}{\partial \theta} = \frac{p^I}{E \int V_{KK}(\cdot) f^{s'}(h'|h)dh'} - \frac{E \int V_{K\theta} f^{\alpha,s'}(\alpha'|\alpha) f^{A,s'}(A'|A) \left(\partial F^{\theta,s'}/\partial \theta\right) d\alpha' dA' d\theta'}{E \int V_{KK}(\cdot) f^{s'}(h'|h)dh'} \tag{8}$$

where $\partial F^{\theta,s'}/\partial\theta \equiv \partial F^{\theta,s'}(\theta'|\theta)/\partial\theta$is the derivative of the cumulative distribution function of θ' with respect to the conditioning variable θ. The first term in (8) is the negative cost effect as in (7). The second term captures the information effect and will be positive when θ is positively serially correlated, since $\partial F^{\theta}/\partial\theta \leq 0$ by FSD, and $V_{K\theta} < 0$. While the total effect is ambiguous, the information effect tends to be quantitatively small so that the cost effect dominates and investment is negatively affected. When θ is negatively serially correlated, the sign of $V_{K\theta}$ is theoretically indeterminate, but $\partial F^{\theta}/\partial\theta \geq 0$. In this case, if $V_{K\theta} < 0$ then the information effect is negative, so that both the cost and the information effect of an increase in the interest rate depress current investment.[14]

We can also examine the impact of changes in the risk premium in interest rates on the endogenous risk premium that enters first-order condition for an interior choice of investment as (5).

$$c_t + \Phi_t = (1 - \tau_{t+1}) E_t \Pi_K \left(K_{t+1}, \alpha_{t+1}, A_{t+1}, w_{t+1}\right), \tag{9}$$

where the expectation $E_t(\cdot)$ also includes the expectation over the regime shift probabilities. The right-hand side of (9) is the marginal benefit of investing an additional unit. The left-hand side is the total marginal cost, which is the sum of the Jorgensonian *cost of capital*, c_t, and of a time-varying marginal irreversibility *risk premium* when the firm invests an additional unit, namely, Φ_t.

As can be seen, the risk premium in interest rates raises the current cost of capital thus lowering investment. In addition, in the *i.i.d.* case, a shift in the distribution of θ_t in the "good" regime makes it more likely that investment will be constrained in the future so that Φ_t rises. In turn, a higher irreversibility risk premium lowers investment at time t. Under reasonable assumptions, a similar conclusion will hold when θ is serially correlated. Thus, the irreversibility risk premium rises with stochastically higher interest rates. In other words, the cost of capital effect and the irreversibility premium effect of higher interest rates both contribute to reducing current investment even in the "good" regime. While we did not implement

[14] Altuğ, Demers and Demers (2009) shows that the information effect of a change in the investment tax credit (γ) is small so that with positive serial dependence, the cost effect dominates the information effect. They also show numerically that $V_{K\gamma}$ has the same sign for negative as well as positive serial dependence.

simulations for the case of Russia with stochastically changing interest rates, we expect to obtain the same results as in Altug, Demers and Demers (2007) in terms of the impact of probabilistically higher interest rates (as observed in the Russian experience) to lead to further declines in real investment.

6 Numerical Issues

We now parameterize the model to examine the impact of political risk on investment in Russia. There are several steps in this procedure. First, to account for non-stationary behavior in the exogenous series such as α_t, A_t, and w_t, we propose a stationarity-inducing transformation that allows us to formulate a stationary version of the firm's dynamic programming problem. Next, we estimate processes for the stationary versions of the exogenous series. Third, we present simulations of the model under alternative scenarios.

6.1 The stationarity-inducing transformation

In our application, we associate the demand shock α_t with oil prices, the technology shock A_t with total factor productivity, and w_t as real hourly earnings. We measure the firm's profit function in real rubles. However, an initial examination of the data on these quantities shows that they possess unit roots and potential non-stationary behavior. To account for this, we use the form of the profit function that yields a stationary representation for the firm's problem in terms of the quantities $\tilde{k}_t \equiv K_t/\alpha_t$, $g_{\alpha,t} \equiv \ln(\alpha_t/\alpha_{t-1})$, $\tilde{w} \equiv w_t/A_t$, and $g_{A,t} \equiv \ln(A_t/A_{t-1})$.

To derive this representation, define

$$v(\tilde{k}_t, \tilde{w}_t, s_t = i) \equiv \frac{V(K_t, \alpha_t, A_t, w_t, s_t = i)}{\alpha_t A_t^{\mu_2}}.$$

Then

$$
\begin{aligned}
v(\tilde{k}_t, \tilde{w}_t, s_t = i) &= \frac{\upsilon \alpha_t^{\mu_1} K_t^{1-\mu_1} A_t^{\mu_2} w_t^{\mu_4}}{\alpha_t A_t^{\mu_2}} - \frac{p_t^I (K_{t+1} - (1-\delta) K_t}{\alpha_t A_t^{\mu_2}} \\
&\quad + \frac{\beta \sum_{j=0}^{1} E_t \chi_{ij} V(K_{t+1}, \alpha_{t+1}, A_{t+1}, w_{t+1}, s_{t+1} = j)}{\alpha_t A_t^{\mu_2}} \\
&= \upsilon \tilde{k}_t^{1-\mu_1} \tilde{w}_t^{\mu_4} - \frac{p_t^I}{A_t^{\mu_2}} \left(\exp(g_{\alpha_{t+1}}) \tilde{k}_{t+1} - (1-\delta) \tilde{k}_t \right) \\
&\quad + \beta \sum_{j=0}^{1} E_t \left[\chi_{ij} v(\tilde{k}_{t+1}, \tilde{w}_{t+1}, s_{t+1} = j) \exp(g_{\alpha_{t+1}}) \exp(\mu_2 g_{A,t+1}) \right],
\end{aligned}
$$

where we have made use of the fact that $\mu_2 = 1 - \mu_1$ and $\mu_2 = \mu_3 + \mu_4$. For the value function to be well defined and bounded, we require the additional condition that[15]

$$
\beta E_t[\exp(g_{\alpha_{t+1}}) \exp(\mu_2 g_{A,t+1})] < 1.
$$

Note that this representation assumes that the growth rates of the oil price and of technological change, $g_{\alpha,t}, g_{A,t}$ as well as normalized wages and the price of capital, w_t/A_t and $p_t^I/A_t^{\mu_2}$, are stationary. In the next section, we use data for the Russian economy to show that the first three assumptions are empirically substantiated. Unfortunately, we were unable to find data on the implicit price deflator for investment to measure the price of capital, p_t^I. If p_t^I and $A_t^{\mu_2}$ grow at similar rates, however, then their ratio will be stationary. In the absence of data on p_t^I, we assume that this ratio is approximately constant.

6.2 Estimating processes for the exogenous series

We now turn to estimating processes for the growth rates of the real price of oil and of technology shocks as well as the normalized value of real earnings.

In our analysis, we model the stochastic process governing oil prices as a 2-state Markov switching process, with the two states corresponding to falling and rising prices.[16] As is well known, the Russian Federation is one of the largest producers

[15] See Altug and Labadie (2008), Ch. 8.

[16] For a recent application of this approach in modeling the oil price, see Zou and Chen (2013).

and exporters of hydrocarbon products such as oil and gas. The sanctions regime that has been imposed on Russia due to its actions in Ukraine has coincided with the advent of low oil prices that have fallen as far as $30 per barrel by January, 2016 from highs of $116 per barrel in July, 2011. Hence, we associate the sanctions regime with the regime with falling oil prices. To further capture recent changes in the Russian terms of trade due to the sanctions regime, we denominate the profit function in real rubles and generate the real price of Brent oil in rubles.

To describe the Markov switching model for oil price changes, denote g_{ot} as the growth rate of the real ruble price of Brent oil. The Markov switching model stipulates that there exists an unobserved discrete variable denoted by s_t that determines the evolution of a variable y_t (defined as g_{ot} in this case) as

$$y_t = \nu(s_t) + \rho_y y_{t-1} + \sigma(s_t)\epsilon_t, \tag{10}$$

where $\nu(s_t), \sigma(s_t)$ denote the regime switching mean and standard deviation of g_{ot} and ρ denotes the constant autoregressive coefficient. The transition probabilities for the states are denoted by

$$Pr(s_{t+1} = j|s_t = i) = p_{ij}, \;\; i = 0, 1; \text{ and } \sum_{j=0}^{1} p_{ij} = 1 \text{ for all } i. \tag{11}$$

Thus, this specification allows the dynamics of the growth rate of the oil price to be affected by the unobserved state variable s_t in terms of its mean and its variance. [17] This model is referred to as the Markov switching dynamic regression model following Krolzig (1997).

Table 1 shows the estimates of our preferred Markov switching dynamic regression for the growth rate of oil prices using quarterly observations. The null hypothesis of a linear autoregressive model is strongly rejected according to the Likelihood Ratio test with a p-value of zero, suggesting that the assumption of regime switches

[17] Hamilton (1989) formulated the Markov switching model to explain US business cycles. Subsequent applications have focussed on a variety of phenomena, including the stochastic behavior of interest rates, exchange rates, as well as oil prices and oil futures.

	Regime		Probabilities	
	0	1	p_{00}	p_{01}
$\nu(s_t)$	-0.0505	0.01885	0.887	0.113
	(-1.44)	(2.96)	(10.8)	-
$\sigma(s_t)$	0.1570	0.0747	p_{10}	p_{11}
	(8.55)	(15.2)		
ρ	0.1488	-	0.0316	0.9684
	(2.18)		(1.61)	-

t-statistics in parentheses

Table 1: Estimates of the Markov Switching Model for Oil Price Changes

in the growth rate of the oil price is supported by the data. Here we observe that real ruble-denominated oil prices experience a decline of over $\nu(s_0)/(1-\rho_\alpha) = 0.0505/(1-0.1488) = 6\%$ in regime 0 while in regime 1, real oil prices are expected to increase by $\nu(s_1) = 0.01885/(1-0.1488) = 2.2\%$. The Markov switching structure also characterizes the standard deviations of the growth rate of oil prices, with a volatility of $\sigma(s_0)/\sqrt{1-\rho_\alpha^2} = (0.1570)/\sqrt{1-0.1488^2} = 15.88\%$ experienced on average in regime 0 that is more than twice the volatility of $\sigma(s_0)/\sqrt{1-\rho_\alpha^2} = (0.0747)/\sqrt{1-0.1488^2} = 7.55\%$ in regime 1. There is also evidence for persistence in the growth rate of the oil price even after controlling for switching means and variances in that the estimate of the autoregressive parameter ρ is significantly different from zero. The Markov switching model also delivers estimates of the probabilities of remaining in the different regimes. Here we observe that the probability of remaining in regime 0 with falling oil prices is less than the probability of remaining in the regime with increasing oil prices. This implies that the expected duration of the regime with falling oil prices is estimated to be $E(d_0) = 1/(1-p_{00} = 8.85$ quarters while the expected duration of the regime with rising oil prices is estimated to be $E(d_1) = 1/(1-p_{11}) = 31.6$ quarters.

In Figure 15, we display the actual and fitted values of the growth rate of the oil price together with the smoothed probabilities of regime 0 and regime 1 with falling and increasing oil prices, respectively. Here we observe that the periods corresponding to 1998-1999, the global financial crisis during 2008-2009 as well as the period beginning in the latter half of 2014 and lasting until the current period correspond to the main episodes with falling oil prices. Here the smoothed probabilities of being in regime 0 are nearly 1. While there are also some short episodes during 2000-2001, the estimated probabilities of the regime with falling oil prices are typically smaller during these periods.

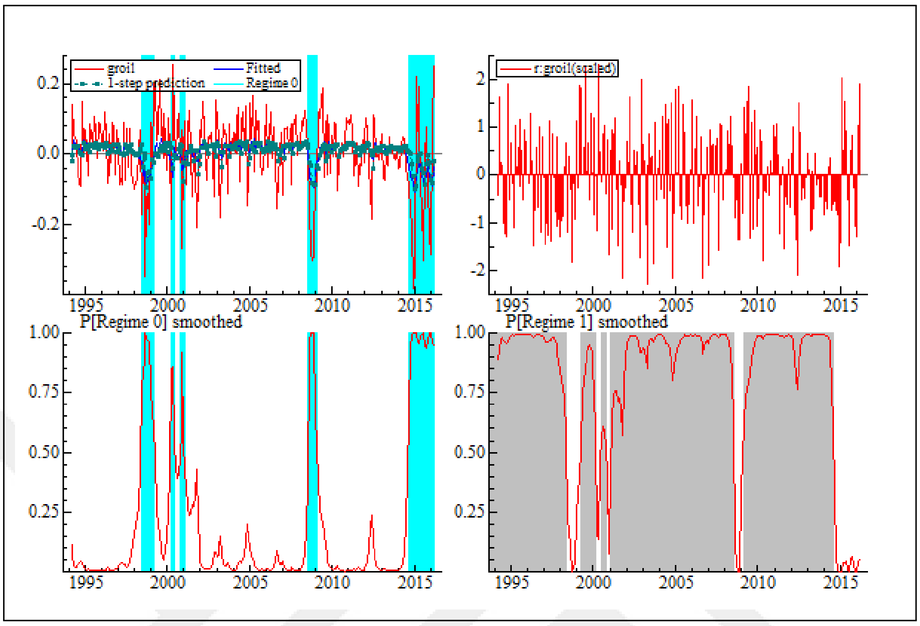

Figure 15: Estimated Markov Switching Model for the Real Oil Price Changes

Next, we turn to estimating a regime-switching process for the TFP growth rate using annual observations. Table 2 shows the results of this estimation. The null hypothesis of a linear model for describing TFP growth is also rejected in this case in that the Likelihood Ratio statistic is equal to 10.12, which implies a p-value of 0.0385. The estimates for $\nu(s_t)$ and $\sigma(s_t)$ imply that TFP growth is negative in regime 0, with an average rate of $\nu(s_0)/(1-\rho_A) = -6.3\%$ and it is equal to nearly positive $\nu(s_1)/(1-\rho_A) = 5.7\%$ in regime 1. Likewise, we observe significant differences in the volatility of TFP growth in regimes 0 and 1, which vary between 5% and 1.6%. We observe that probability of remaining in each regime is less persistent compared to changes in the oil price. Nevertheless, the values of p_{00} and p_{11} are both greater than 0.75. Finally, Figure 16 shows the periods that coincide with the incidence of regimes 0 and 1, respectively. We observe that the period following the transition after the collapse of the Soviet Union is associated with the largest declines in TFP, as the Russian economy adjusts to the market economy through a "Shock Therapy" approach (Rutland 2013). The second episode of fall in productivity growth is associated with the global financial crisis of 2009.

	Regime		Probabilities	
	0	1	p_{00}	p_{01}
$\nu(s_t)$	-0.0540	0.0484	0.7496	0.2504
	(-2.54)	(7.94)	(4.26)	-
$\sigma(s_t)$	0.0495	0.0157	p_{10}	p_{11}
	(3.41)	(4.76)		
ρ	0.1442	-	0.1277	0.8723
	(1.48)		(1.08)	-

t-statistics in parentheses

Table 2: Estimates of the Markov Switching Model for TFP Growth

Surprisingly, there is no evidence of TFP declines during the sanctions regime that has been in place since 2014. However, we observe that the growth rate of TFP has been declining since 2010, a phenomenon that many commentators have noted as the increasing loss of competitiveness for the Russian economy in recent years and the need for further reforms to stimulate further increases in productivity.

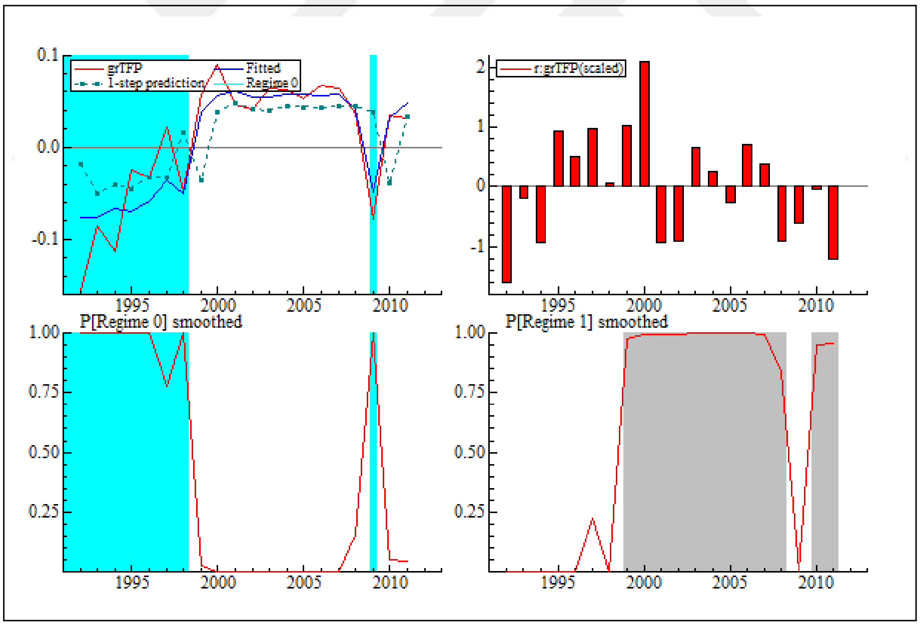

Figure 16: Estimated Markov Switching Model for the Russian TFP growth

The final process that we estimate is for normalized hourly real earnings, $\tilde{w}_t$ denominated in rubles. Here we only estimated a first-order autoregressive process, as we could not identify a Markov switching model that differentiated adequately between the two potential regimes.[18] Due to potential measurement in this series, we opted for a simpler autoregressive specification as follows:

[18]Specifically, the estimates of a 2-state Markov switching model implied positive means in both states.

Demand		Normalized Wages	
ϵ	-3	ν_w	0.4104
Production			(1.87)
η	0.3	ρ_w	0.9055
Discount Factor			(18.2)
β	0.95	σ_w	0.0551
Depreciation rate	0.025		

t-statistics in parentheses

Table 3: Remaining Parameters

$$\tilde{w}_t = \nu_w + \rho_w \tilde{w}_{t-1} + \sigma_w \epsilon_{w,t}. \tag{12}$$

The estimated process for normalized wages together with the remaining parameters characterizing the problem are displayed in Table 3.

7 Simulation Results

We now present the results of simulating the model under alternative scenarios. We use the method of numerical dynamic programming with a discretized grid for $\tilde{k}_t$, $g_{\alpha,t}$, $g_{A,t}$, and $\tilde{w}_t = w_t/A_t$. We use the method in Tauchen (1986) to approximate continuous AR(1) processes with discrete first-order Markov processes to generate the grids for the exogenous series $g_{\alpha,t}$, $g_{A,t+1}$, and $\tilde{w}_t = w_t/A_t$, which we assume are lognormally distributed. To generate a grid for the normalized capital stock, $\tilde{k}_t$, we first derive the deterministic steady state capital stock implied by the model. This is obtained by considering the first-order condition and envelope condition for the optimal choice of investment as follows:

$$\begin{aligned} v(\tilde{k}_t, \tilde{w}_t, s_t = i) &= \max \tilde{I}_t \Big\{ \upsilon \tilde{k}_t^{1-\mu_1} \tilde{w}_t^{\mu_4} - \frac{p_t^I}{A_t^{\mu_2}} \Big(\exp(g_{\alpha_{t+1}}) \tilde{k}_{t+1} - (1-\delta)\tilde{k}_t \Big) \\ &\quad + \beta \sum_{j=0}^{1} E_t \Big[\chi_{ij} v(\tilde{k}_{t+1}, \tilde{w}_{t+1}, s_{t+1} = j) \exp(g_{\alpha_{t+1}}) \exp(\mu_2 g_{A,t+1}) \Big] \Big\} \end{aligned}$$

subject to $\exp(g_{\alpha,t})\tilde{k}_{t+1} = (1-\delta)\tilde{k}_t + \tilde{I}_t$. The relevant first-order and envelope conditions are given by

$$-\frac{p_t^I}{A_t^{\mu_2}} + \beta_t \sum_{j=0}^{1} E_t \left[\chi_{ij} \frac{\partial v(\tilde{k}_{t+1}, \tilde{w}_{t+1}, s_{t+1} = j)}{\partial \tilde{k}_{t+1}} \exp(g_{\alpha_{t+1}}) \exp(\mu_2 g_{A,t+1}) \right] = 0,$$

with

$$\frac{\partial v(\tilde{k}_t, \tilde{w}_t, s_t = i)}{\partial \tilde{k}_t} = \upsilon(1-\mu_1)\tilde{k}_t^{-\mu_1}\tilde{w}_t^{\mu_4} + (1-\delta)\frac{p_t^I}{A_t^{\mu_2}}.$$

Simplifying and assuming that the shocks to all of the exogenous processes are set equal to zero for the "good" regime, we obtain an expression for the steady state capital stock as

$$\tilde{k}^s = \left[\frac{\upsilon(1-\mu_1)\exp(\mu_4\nu_w/(1-\rho_w))\exp(\mu_2\nu_A(s=0))/(1-\rho_A))}{1-\beta(1-\delta)\exp(\mu_2\nu_A(s=0))/(1-\rho_A))} \right]^{1/\mu_1}. \quad (13)$$

The capital grid is determined as an equi-spaced grid that is $\pm(1+dev)k^s$, where $0 < dev < 1$.

We consider the behavior of a benchmark investment model with one which incorporates some aspect of the experience of political risk in Russia. We provide 400 simulations of 200 periods, with a burn-in sample of 200. We consider 50 points in the discrete grid for the exogenous shocks, and an equi-spaced grid of 100 points around the steady state capital stock. We initially assume that the firm is in the "good regime" characterized by a high mean and low variance for oil price changes and TFP growth estimated from the Markov processes for these series. Figure 17 shows the simulated behavior of investment starting from three different capital stocks for a sample of 200 periods, averaged across 400 simulations.[19] Here we assume that the regime shifts probabilities $\chi_{01} = 0.2, \chi_{10} = 0.2$, namely, that the probabilities from switching from the "good" and "bad" regime are identical and equal to 0.2. We observe that investment fluctuates around an average level of 0.017.[20] As a point of comparison, we then simulate the model where the regime

[19]In these simulations, we average over the zero and non-zero values of investment.

[20]We cannot calibrate the level of investment directly because we have not calibrated the level of the profit function. The model delivers solutions for the ratio of investment to the level of

shifts probabilities are increased to $\chi_{01} = 0.4, \chi_{10} = 0.4$ in Figure 18. We observe that investment behavior in the "good" regime falls because the probability of shifting to the "bad" regime increases to 0.4 from 0.2. This occurs even though the probability from exiting from the "bad" regime also increases to 0.4 from 0.2.

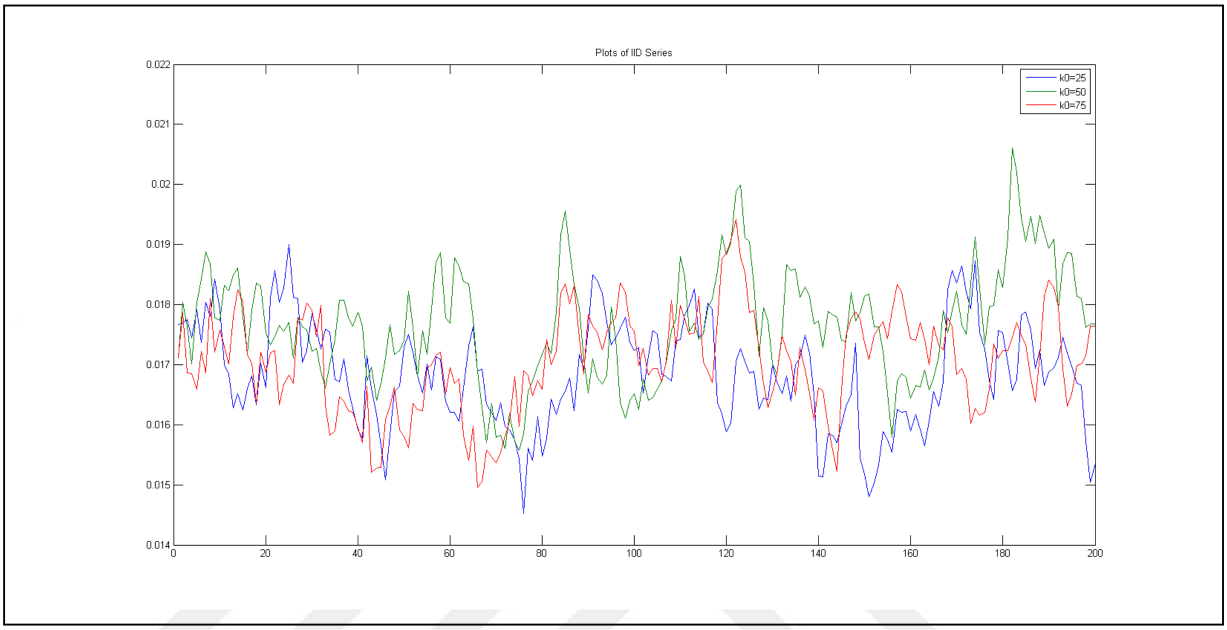

Figure 17: Investment behavior in the "good" regime with regime shift probabilities of $\chi_{01} = 0.2, \chi_{10} = 0.2$.

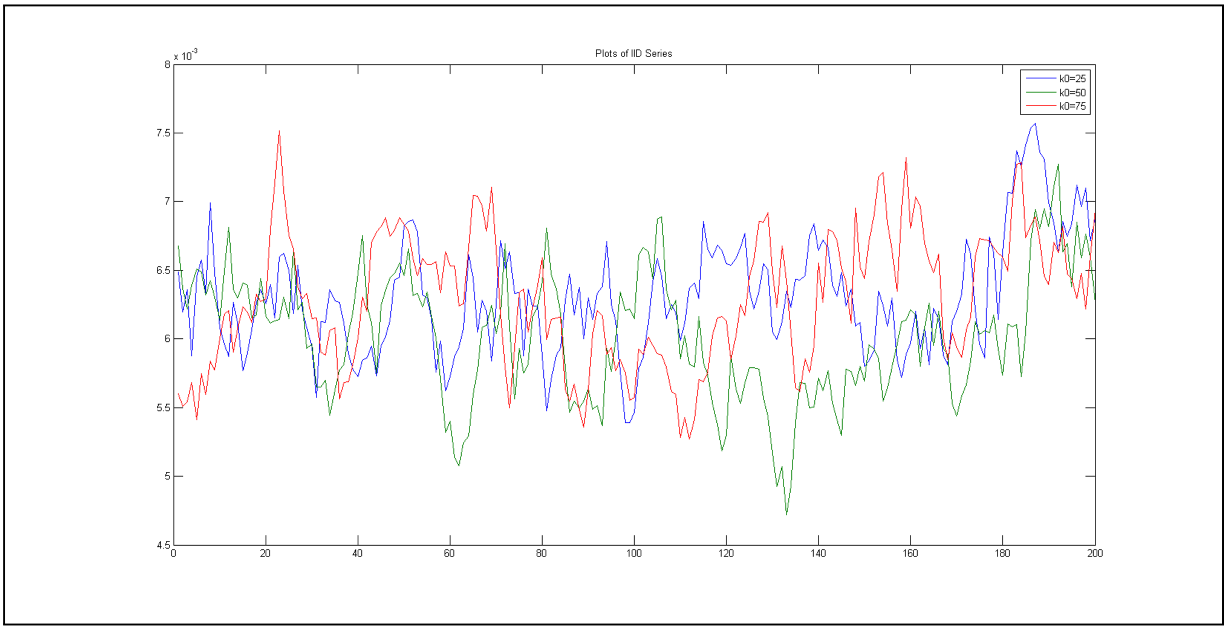

Figure 18: Investment behavior in the "good" regime with regime shift probabilities of $\chi_{01} = 0.4, \chi_{10} = 0.4$.

demand shock α_t, namely, $\hat{I}_t = I_t/\alpha_t$ as function of the stationary variables $\hat{k} = K_t/\alpha_t, \hat{w}_t = w_t/A_t, gr_{A,t+1}, gr_{\alpha,t+1}$. For illustrative convenience, we multiply the simulated values of $\hat{I}_t$ with the initial value of $\alpha_0 = 600$ rubles.

Next, we simulate investment behavior conditional on being in the “bad regime”, where the behavior of normalized investment is displayed in Figure 19. As before, we consider the probability of exiting each regime to equal 0.2 and 0.4, respectively. Now, investment falls because investors know that they face unfavorable fundamentals such as low growth in TFP and demand with high probability. Hence, when investment is irreversible and they know that the “bad” regime will last with probability $1 - \chi_{10} = 0.8$, then they cut back on investment in a significant way. Normalized investment is now less than a third of its value in the “good” regime with identical regime shift probabilities.

What happens when investors’ perceived probability of leaving the “bad” regime is zero? We can refer to this situation as the “bad” regime being an absorbing state. The results are displayed in Figure 20. We observe that investment falls even more: not only is investment lower compared to the case when agents expect to exit the “bad” regime with probability equal to 0.2, it attains values that are nearly a tenth of its value in the “good’ regime when the value of exiting this regime is equal to 0.2.

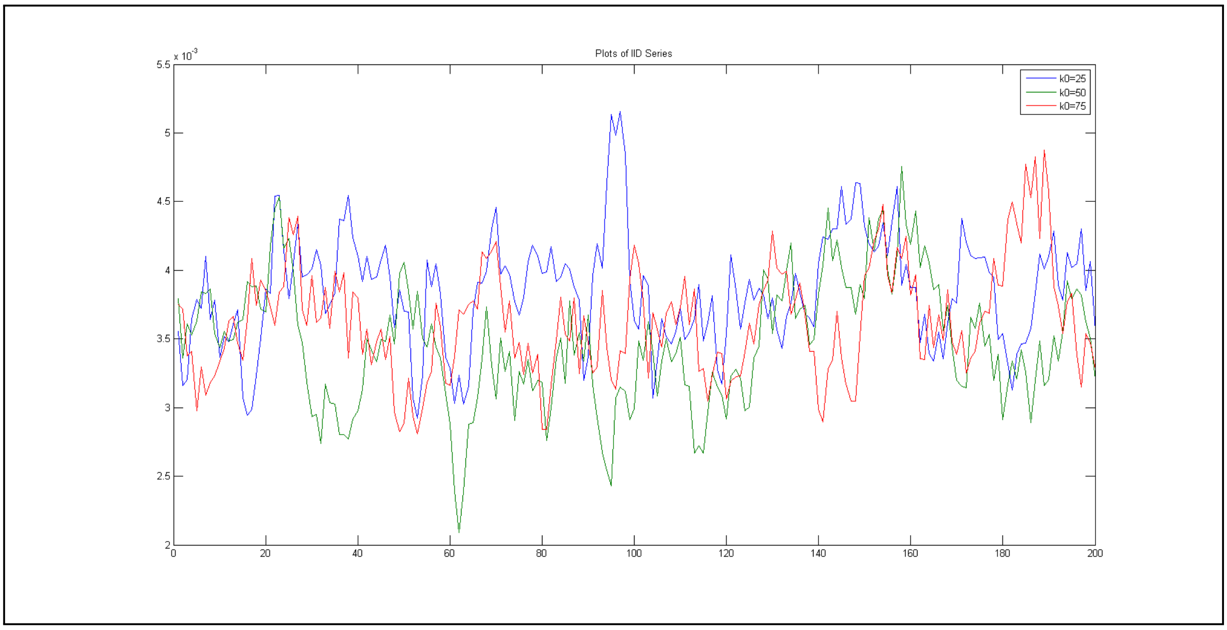

Figure 19: Investment behavior in the “bad” regime with regime shift probabilities of $\chi_{01} = 0.2, \chi_{10} = 0.2$

Now we consider a situation the economy can exit from one regime to the other in the existing period. Figure 21 show the behavior of normalized investment

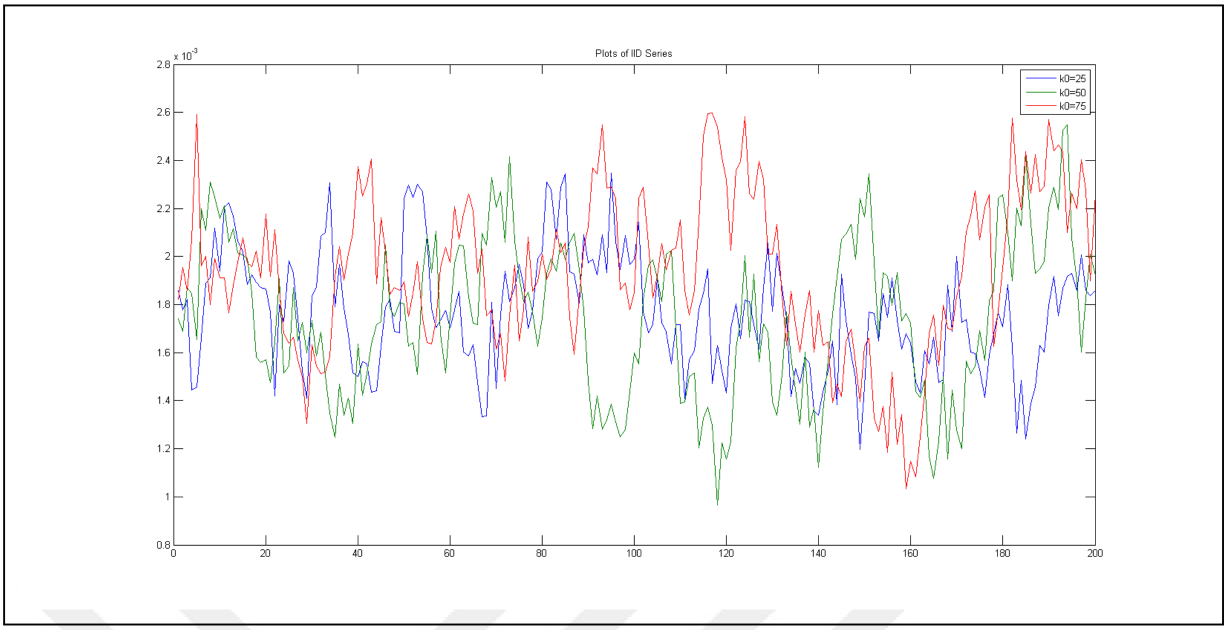

Figure 20: Investment behavior in the "bad" regime with regime shift probabilities of $\chi_{01} = 0.4, \chi_{10} = 0$

when the probability of exiting each regime is 0.2. Here we assume that the economy is in the "bad" regime during the burn-in sample of 200 periods, and transits to the "good" regime after $t = 200$. We observe that the behavior of investment is somewhat lower than that when the economy stays in the "good" regime throughout the entire simulation period. In Figure 22, we consider the opposite situation, where the economy starts off in the "good" regime and transits to the "bad" regime after $t = 200$. Here we assume that $\chi_{01} = 0.4, \chi_{10} = 0$ so that once the economy transits to the "bad' regime, it will stay there forever. In this case, investment is similar to the case when the economy starts out and stays in the "bad" regime forever.

As we discussed in Section 4, we do not believe the sanctions regime is an absorbing state for the Russia Federation, though it is commonplace that such regimes tend to be quite persistent.[21] Hence, these observations provide some justification for our examining the case with an absorbing state.

In Table 4, we also display the unconditional mean and the coefficient of variation

[21] An example of an absorbing sanctions regime is the case of Iran. The sanctions that have been imposed in 1979 against Iran were not lifted–were expanded several times– until January 2016, which corresponds to more than 30 years. Even though from the perspective of today the sanctions regime ended, the probability of switching to regime with sanctions lifted seemed close to zero a couple decades ago while sanctions were being expanded.

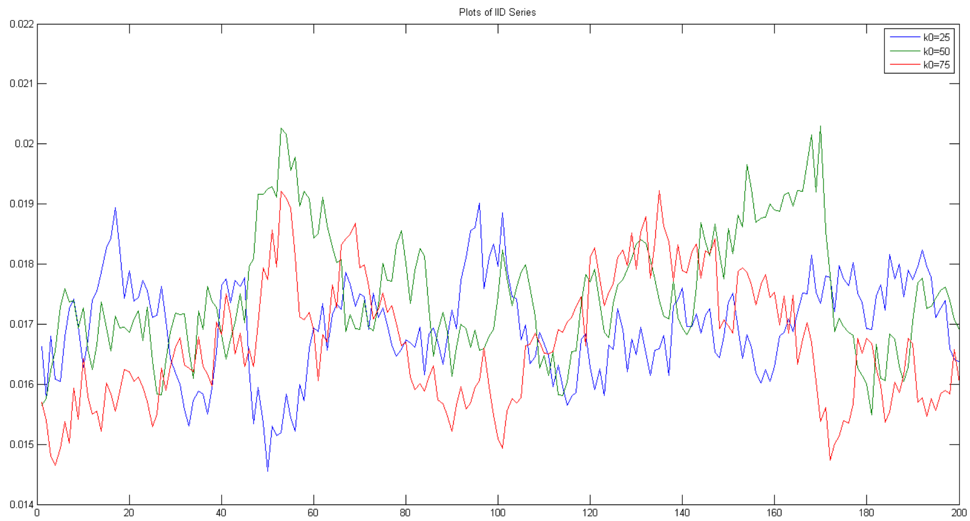

Figure 21: Investment behavior when the economy transits from the "bad" regime to the "good" regime with regime shift probabilities of $\chi_{01} = 0.2, \chi_{10} = 2$

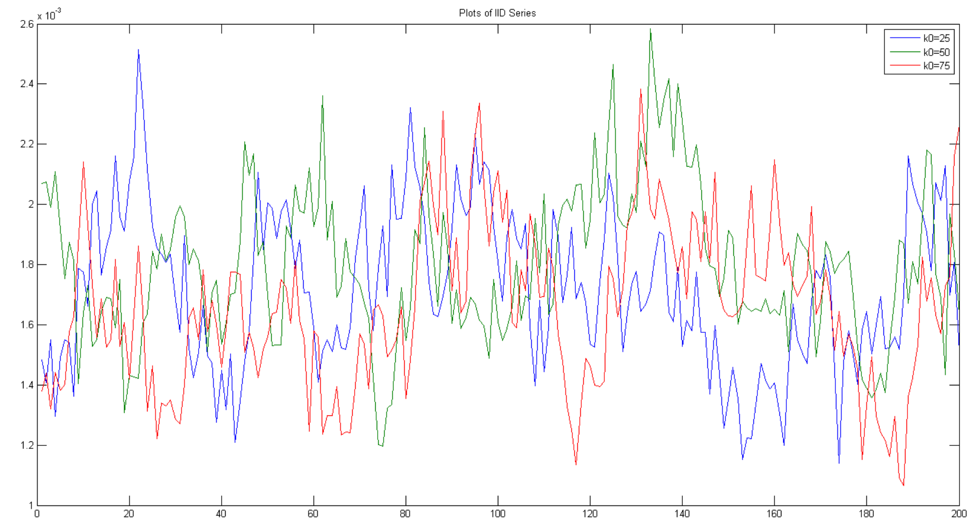

Figure 22: Investment behavior when the economy transits from the "good" regime to the "bad" regime with regime shift probabilities of $\chi_{01} = 0.4, \chi_{10} = 0$

of investment, $CV = STD(I)/E(I)$ averaged over the simulated histories that are of 200 periods length. This provides information on the mean and variability of normalized investment under the alternative scenarios. The information on the unconditional mean merely corroborates what we demonstrated in Figures 17 to 22. Second, we observe that the coefficient of variation is the lowest when the economy starts out in the "good" regime and stays forever there, and it is the

	Summary Statistics	
	$E(I)^{\dagger}$	CV
I. $\chi_{01} = 0.2, \chi_{10} = 0.2,$		
(i) Good regime only	0.0172	1.2291
(ii) Bad regime only	0.0036	2.5906
II. $\chi_{01} = 0.4, \chi_{10} = 0.4$		
(i) Good regime only	0.0113	1.5100
(ii) Bad regime only	0.0071	1.9941
III. $\chi_{01} = 0.4, \chi_{10} = 0$		
(i) Good regime only	0.0116	1.5150
(ii) Bad regime only	0.0018	3.4481

Table 4: Regime Shifts

highest for the "bad" regime which is an absorbing state. We also notice that the existence of an absorbing state tends to increase the volatility of investment even if the "bad" regime is never realized in the sample. Finally, we note that the average level of investment together with its variability tend to become closer as (i) the probability of exiting the "good' regime increases (χ_{01} increases) and (ii) the probability of exiting the "bad" regime falls (χ_{10} falls). This is evident in the comparison of cases I. and III. in Table 4.

8 Conclusion

This paper provides a new perspective on investment outcomes that are shaped by political risk and uncertainty present for the case of Russian Federation using oil prices and TFP as indicators of bad regime that results from higher political risk. We fit a Markov Switching Model for the real oil price and TFP growth for Russia and simulate the model under alternative scenarios, including a hypothetical absorbing state where the probability of switching regimes is zero.

This study has policy implications that even when in the "bad" regime, if the probability of switching to the "good" regime increases, investment behavior tends to improve and become more similar to the investment behavior in the "good" regime. Thus, countries which find themselves in the "bad" regime due to the existence of sanctions, for example, may improve their performance even under such adverse conditions if they also succeed in improving the perception of their eventual shift from such conditions. Nevertheless, our results demonstrate that conditions for economies that experience the "bad" regime, whether they were originally in that regime and stayed there or they transited there from the "good" regime, are much worse than being in the "good regime initially or succeeding in exiting this regime and transiting to the "good" regime eventually.

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A Data

The data used in this thesis were taken from various resources. The data on investment figures are taken from Central Bank of Russia. The economic policy uncertainty index, oil price series and TFP data are derived from Federal Reserve Bank of St. Louis, where their original sources vary. The real wage series, political risk score, refinancing rate, the Russian stock data are taken from Bloomberg. The detailed descriptions of individual series and their sources are as follows:

Total Factor Productivity The data is downloaded from FRED and the source is University of Groningen, University of California, Davis. TFP is downloaded annually at constant national prices for Russian Federation and the index is equal to 1 in 2005. We divide every number to the index in 2010 to equal it to 1 in 2010 as in most other indices in our dataset.

Production in Total Manufacturing in Russia Organization for Economic Co-operation and Development

GDP Index FRED, Organization for Economic Co-operation and Development.

Total Energy Production Index Organization for Economic Co-operation and Development

Total Industry Production Excluding Construction Index Organization for Economic Co-operation and Development

RUMEREAL Wage index for the Russian economy. Downloaded from Bloomberg Terminal.

Oil Price Data Federal Reserve Bank of St. Louis, Global Price of Brent Oil. The source of FRED is the International Monetary Fund. The series is downloaded monthly in U.S. dollars and is converted to real terms in Russian rubles by using the real quarterly exchange rate. Nominal quarterly oil prices are calculated too.

Broad Effective Exchange Rate for Russia FRED, Bank for International Settlements.

Real Broad Effective Exchange Rate for Russia FRED, Bank for International Settlements. The series is downloaded monthly and we convert it to quarterly terms. It is equal to 100 in 2010.

Monthly Earnings This series is used to get real hourly wage information for Russian Federation. First the monthly wage is divided by 120, an average of working hours for a month and Consumer Price Index is used to get real hourly wage series.

Implicit GDP Price Deflator in Russian Federation FRED, Organization for Economic Co-operation and Development.

Consumer Price Index for Russian Federation FRED, Organization for Economic Co-operation and Development.

Real GDP in Russian Federation First the Current Price Gross Domestic Product in Russian Federation series is downloaded in billions of Russian rubles from FRED, Organization for Economic Co-operation and Development and then Russian GDP Implicit Price Deflator is used to get Real Russian GDP.

Real Private Consumption Quarterly Private Consumption Expenditures in Russian Federation series is downloaded in billions of Russian rubles and Russian GDP Implicit Price Deflator is used to get Real Russian GDP.

Real Government Consumption Government Final Consumption series is downloaded in billions of Russian rubles and is converted to real government consumption using Russian GDP Implicit Price Deflator.

Real Capital Formation Gross Fixed Capital Formation in Russian Federation is in billions of Russian rubles and its source is FRED, Organization for Economic Co-operation and Development. Implicit price deflator is used to calculate real fixed capital formation to get real investment.

Direct Investment in Russian Federation The Central Bank of Russia is the source for direct overall investment in Russian Federation. The investment series is quarterly in millions of U.S. dollars and we use real quarterly exchange rate and price deflator to get real direct investment data in billions of Russian rubles.

Total Industrial Production in Russian Federation The data are taken from the FRED, whose source is listed as the *Organization for Economic Co-operation and Development.*

Total Energy Production in Russian Federation The data are taken from the FRED, whose source is listed as the *Organization for Economic Co-operation and Development.*

GDP index The data are taken from the FRED, whose source is listed as the *Organization for Economic Co-operation and Development.*

Total energy investment in Russia and the energy rent data are taken from World Development Indicators database.