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BRIC by BRIC.

Governance and Energy Security in Developing Countries.

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Abstract

Security of energy supply is a top priority of policymakers around the globe, especially in countries of the economically emerging world. This paper's aim is to investigate the link between the mode of governance in four developing countries and the way policies to secure energy supply are established. The paper looks at the four "BRIC" countries, Brazil, Russia, India, and China. These countries are experiencing rapid economic growth and poverty alleviation but differ in their modes of governance. The four BRIC countries provide a window into the particular relationship between governance and energy security policy in developing countries.

From a theoretical stance, a public choice model is applied to energy policies to develop hypotheses relating the similarities and differences of incentive schemes between democratic and authoritarian governments to predict policy outcomes. We hypothesize that authoritarian regimes seek control and the capability to reward and repress social groups by providing public goods, such as energy supply.

In the first empirical step, the current energy economic performance is examined by focussing on domestically available resources, de-concentration and decentralization of the supply side and energy development indices. Doing so, the paper modifies the Kaya Identity to figure out the drivers of energy demand. Furthermore, the paper introduces some metrics such as the Herfindahl-Hirschman-Index (HHI) to measure degrees of concentration and centralization and radar-charts to illustrate the metrics graphically. According to our calculation, Russia's electricity generation park is geographically most centralized. China and Russia have the largest plants by mean output and show the lowest degree of concentration. Referring to indicators, ranging from electricity distribution losses, access to electricity, to the consumption to production ratio, and others, the research finds China to have the most secure energy supply among the BRIC countries, while India performs poorly.

Energy policies to foster supply security are compared in the paper's second empirical part. It includes systematic in-depth analyses of the government-driven utilization of National Oil Companies (NOCs) and the construction processes of hydroelectric dams. China seems to be able to exclude social, political and environmental costs, prioritizing economic growth over other objectives. This allows Chinese power plants to be built in a faster and in a cheaper way. Finally, evidence is provided that authoritarian systems tend to utilize NOCs for their political purpose. The paper concludes that there is a significant relation between the mode of governance and the way energy supply is secured. As the rest of the developing world industrializes, investigating the BRIC countries now, during their period of transition, provides clues into how other developing countries might respond to the challenges of securing the supply of energy.

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Nomenclature

α	size of power plant
η	elasticity
τ	tax
BCF	billion cubic feet
Btu	British thermal unit
C	consumption
CDM	Clean Development Mechanism
D	energy demand
E	amount of primary energy
F	CO2 emissions
FHI	Freedom House Index
G	public good
GW	giga watt
GWh	giga watt hour
HDI	Human Development Index
HHI	Herfindahl-Hirschman-Index
IOC	independent oil company
IPP	independent power producer
L	loyalty
LNG	liquified natural gas
$MBOE$	million barrels of oil equivalent
MW	mega watt
MWh	mega watt hour
NOC	national oil company
P	power
p	population
PW	peta watt
PWh	peta watt hour
$quad$	1 quadrillion Btu

R	repression
S	security
T_R	tax revenues devoted to activity of repression
TW	terra watt
TWh	terra watt hour
Y	national income
Y_τ	after-tax income

1 Introduction

There are three general goals for energy policy: 1) securing the supply of natural energy resources, 2) consuming and producing energy in an environmental sustainable way, and 3) utilizing energy to allow for economic competitiveness. It is the challenge of policymakers to balance these goals with portfolios of policies to develop and utilize energy technologies, expand and extract energy resources, and clean and protect the environment.

The "BRIC" countries[1], Brazil, the Russian Federation, India, and China, are the four largest world economies among non-OECD members. Over the last decade, 24% of world GDP growth occurred in the economies of the BRIC countries as their economies grew from 8% of the world economy to where they stand today at 15% of global GDP (U.S. Energy Information Administration, 2010c). Managing rapid economic expansion has been a key challenge for policymakers in the BRIC states. Adding to the challenge, large populations demand large quantities of resources, and in 2009, 42% of the world's population lived in a BRIC state (The World Bank, 2010b). Large populations beginning from relative poverty expanding through rapid economic growth have strained policymakers in the BRIC countries to develop energy policy to meet the simultaneous challenges posed by the three goals from above. While the BRIC economies are responsible for both a large fraction of world output and of world output growth, on a per-capita basis, they remain among the poorest countries in the world, with a GDP per capita less than one-fourteenth that of Germany's.

Policymakers in the BRIC states aspire to steer their rapidly growing economies toward the level of development enjoyed by the richest countries. High levels of capital investment and consumption growth will likely keep output growth rates high as the BRIC countries continue in their economic transition. During transition, energy-intensive industries will demand affordable and reliable sources of energy feedstocks and electric power, forcing the economics growth-focused BRIC governments to rank securing and managing energy supply among their top national priorities.

BRIC countries, with the exception of the Russian Federation, have not fully achieved energy autonomy, the capability of (net) domestic primary energy supply to entirely meet domestic demand. Table 1 shows the average annual percent changes in energy production and consumption in the BRIC countries, revealing how rapidly both supply and demand for energy grew between 1980 and 2007. In absolute term, the difference between the growth rate of production and the growth rate of consumption shows the growing excess demand in each country but Russia. In China and India, the growth rate in energy consumption has outpaced the growth rate in

[1] "BRIC" countries is a term introduced by Goldman Sachs Chief Economist Jim O'Neill in 2001 (Wilson and Purushothaman, 2003).

production. Adding pressure to the BRIC countries' abilities to meet their own domestic energy demand, fossil fuels are finite resources with depletion occurring at ever increasing rates.

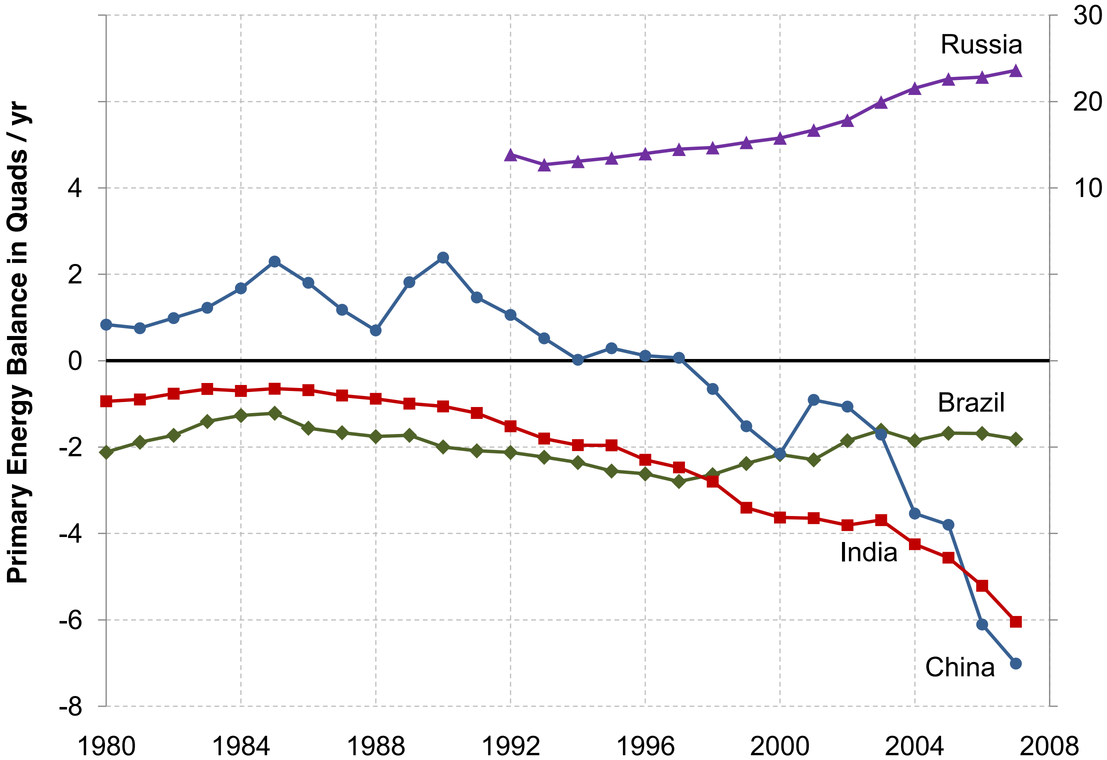
Table 1: Primary Energy Indicators

	Brazil	Russia	India	China
Change in Energy Production (%)	5.72	0.85	5.61	5.32
Change in Energy Consumption (%)	3.52	-0.70	6.00	5.86
Change in Net Energy Balance (%)	2.20	1.55	-0.38	-0.55
Net Energy Balance (quad. Btu)	-1.97	16.59	-2.12	-0.08

Time: 1980 - 2007; average annual change
Source: U.S. Energy Information Administration (2010b); U.S. Energy Information Administration (2010c).

Figure 1 illustrates how consumption is rising faster than production in China and India while Russia's production has outpaced its consumption and Brazil's increased energy demand has been met with roughly equivalent domestic supply.

Figure 1: Primary Energy Balances for 1980-2007



Source: U.S. Energy Information Administration (2010b); U.S. Energy Information Administration (2010c).

Today, the BRIC economies consume 28% of global primary energy, yet on a per capita basis, consumption of energy in BRIC countries is just 24% of the average per capita energy consumption in OECD countries (U.S. Energy Information Administration, 2010c). As the BRIC economies continue to grow, barring any dramatic shifts in technological deployment, their total energy demand per capita will begin to increasingly look like that of wealthier nations. With over 40% of global population, if the BRIC countries consumed as much energy as the OECD countries on a per capita basis, holding all else constant, global energy demand would grow by 90%.

To understand the drivers of energy consumption, we need to clarify which trends drive energy consumption and to what extend they are doing so. The Kaya Identity (1990), shown in Equation (1) and based on the relationships first described by Ehrlich and Holdren (1971), was originally developed as an exact decomposition of human influence on potential social and technical drivers. Inspired by the Kaya Identity, we decompose demand for energy into population, technological and economic drivers in Equation (2).

$$F = \frac{F}{D} * \frac{D}{Y} * \frac{Y}{p} * p \tag{1}$$

$$D = \frac{D}{Y} * \frac{Y}{p} * p \tag{2}$$

Under the decomposition of energy demand in Equation (2), a country's total energy demand, D, is the product of its energy efficiency of economic output, D/Y, its GDP per capita, Y/P, and the size of its population, p. Table 2 quantifies these indicators and provides data on the parameter changes in the BRIC states. Between 2000 and 2007, energy demand grew in each of the BRIC states. China's energy demand rose by 10.1% p.a. India follows with a mean demand growth of 5.0% p.a. Brazil comes third with 2.6% p.a. and Russia's energy demand grew by 1.6% p.a.

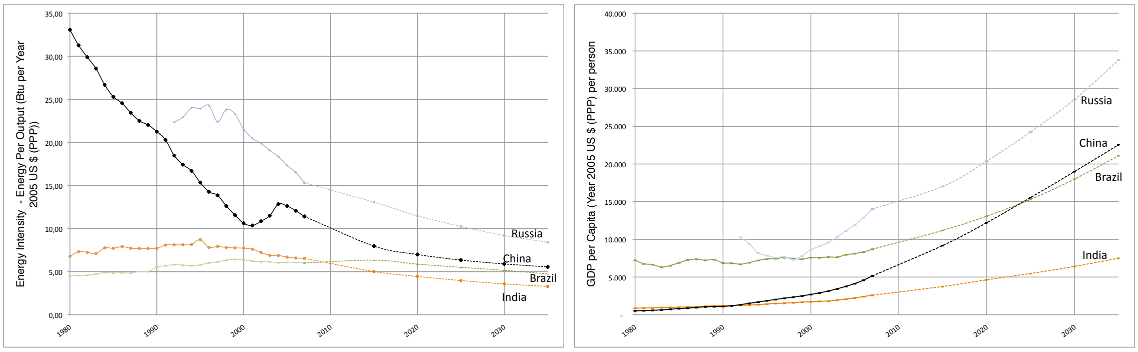
Table 2: Modified Kaya Identity

	Brazil	Russia	India	China
D	0.026	0.016	0.050	0.101
D/Y	-0.008	-0.051	-0.021	0.000
Y/p	0.021	0.076	0.055	0.095
p	0.014	-0.005	0.016	0.006

Time: 2000 - 2007; mean annual growth
Source: U.S. Energy Information Administration (2010b).

It is of interest to figure out the key drivers of the growing demand. We calculate the annual growth rate of the Kaya decomposition factors using $[(Y/p)_t - (Y/p)_{t-1}]/(Y/p)_{t-1}$. According to our data above, GDP per capita (Y/p) had the strongest impact on the rise in energy demand. In each of the BRIC states (Y/p) rose. China leads the increase by an average growth rate of 9.5% p.a. It is followed by Russia (7.6% p.a.), India (5.5% p.a.) and Brazil (2.1% p.a.). The energy intensity of GDP, (D/Y), had a negative effect on the energy demand in Russia (-5.1% p.a.), India (-2.1% p.a.) and Brazil (-0.8% p.a.). It did not change Chinese energy demand. While Russia's declining population-growth-rate (-0.5% p.a.) loosened the pressure on energy demand, in India (1.6% p.a.) and Brazil (1.4% p.a.) the growth of population contributes to the energy demand. China's population growth (0.6% p.a.) ranges below India's and Brazil's. This can be attributed to the country's one-child-policy. Figure 2 illustrates the trends for past and projected years. Projections for 2015-2035 by the EIA (2010b) show energy intensity falling and GDP per capita rising in the BRIC states, suggesting that economic growth may be able to continue in the BRIC countries if they become more energy efficient.

Figure 2: Energy Intensity and GDP per Capita for 1980-2007 with Projection to 2035



Source: U.S. Energy Information Administration (2010c); U.S. Energy Information Administration (2010b).

This article is organized as follows. Section 2 applies a public choice model to energy policy in authoritarian systems. We derive three hypotheses from the theoretical considerations of how types of governments create policies for energy security. They are quantified and tested in section 3.2, 4.1.3 and 4.2, respectively. While this section outlined the similarities among the BRIC states in terms of recent economic history and current economic position, section 2 draws a distinction between the BRIC states in their mode of governance. Following the Freedom House Index, we consider India and Brazil to be democratic regimes and China and Russia to be authoritarian ones. Section 3 quantifies metrics for assessing the current state of energy security in the BRIC states. Section 4 describes the policies enacted by BRIC governments to foster (or in some cases deter) access to energy service, using the variance in governance modality among the BRIC states to contrast the ability of the states to secure energy supplies. Section 5 concludes.

2 Theory and Design

This section develops the theory of authoritarian governance to provide context for the empirical analysis in Sections 3 and 4. First, the section develops a public choice model that explains political behavior of authoritarian regimes. Second, we draw a connection between the theoretical model and our empirical areas of interest. Third, we develop three testable hypotheses of the causal relationship between governance and energy security policy. This section ends with some notes on the methodological design.

2.1 Public Choice Model

Authoritarian regimes and democracies have different kind of incentive settings that underly all their actions. Generally speaking, however, we assume both of them to act rationally in front of their specific incentive-backgrounds. So what is it that drives dictatorships to rule as they do? We approach this question with the standard dictatorship model of pubic choice literature. Despite the fact that the literature usually assumes a dictator to be in charge, we replace this one-person assumption by a group of leaders: the authoritarian regime. This is only a slight change, since there exist few differences between dictators and authoritarian regimes (Wintrobe, 1990; Tullock, 1987). We assume members of the ruling regime to have homogenous policy objectives just like a dictator would. A shared opinion makes them comparable to a single dictator when it comes to decision-making. Therefore it is possible to apply the dictatorship model to authoritarian systems.

More formally, let Y stand for national income and G for the value of a public good. Due to its character, G fosters national income Y in a way that Y is a function of G: $Y(G)$, with $Y' > 0$ and $Y'' < 0$. Financing the production of public goods, the authoritarian regime has to level a proportional tax τ on income Y. Due to the nature of taxes, τ leads to diminishing Y. According to Mueller (2008) the simplest way to capture this negative impact of τ on Y is to assume constant elasticity with respect to the tax rate, η. Hence, the realized income is $Y_r = Y(1 - \eta\tau)$.

Furthermore, the consumption costs of the authoritarian regime itself needs to be met by tax revenues, so that $\tau Y_r = G + C$. Although the authoritarian regime is assumed to be restricted by the budget constraint, it has to be kept in mind that the regime has the option to "nationalize or confiscate resources directly" (Wintrobe, 1998, 59). This means that the leaders of the authoritarian regime want to maximize their consumption subject to this budget constraint. Very generally speaking, authoritarian regimes follow three main goals (Mueller, 2008):

1. consumption

2. power to control the life, mind, and action of the people[2]

3. security to maintain power

Most important in this context are power and the security to sustain it. The dimension of power can be understood as the precondition for the other two goals. For that reason, it is also the most difficult goal to achieve (Tullock, 1987). The security not to be replaced is the core dimension of our analysis. Combining these goals with the standard model we drew above, the utility function of the authoritarians leaders looks as follows:

$$U(P, S, C) \tag{3}$$

P, S and C stand for power, security and consumption, respectively. Authoritarian regimes have an interest in increasing Y because income provides capacity to meet their own consumption as well as share of wealth that their own supporters require.[3] One way of fostering income is to reduce the production of public goods. By this kind of externalization of costs, production of desired goods can be accelerated and comes cheaper. Case in point, air pollution or the destruction of parts of their environment count for environmental costs that can be externalized. The costs have to be met by some other parts of society, however. To be brief, consumption of the regime positively affects its will to survive and vice versa. Economic growth is needed in order to guarantee this relation's persistence.

Following Wintrobe (1990, 1998), authoritarian states choose different tools to sustain their power: Loyalty L stands on the one side, repression R on the other. Furthermore, it is assumed that the loyalty of the citizenship increase with the after-tax incomes, $L = L(Y_\tau)$. Additionally, it is assumed that $L' > 0$, and $L'' < 0$. The level of repression is a function of the sum of tax revenues which is devoted to the activity of repression. It can be written as $R = R(T_R)$, with $R' > 0$ and $R'' < 0$.

As a consequence, authoritarian regimes can try to win the loyalty by making citizens to be better off. One way of achieving this aim is to provide electrification infrastructure and electricity, a better energy supply, so to say. The theoretical model shows that the authoritarian regime can maximize its utility by finding the equilibrium situation where marginal return from tax-sponsored repression equals the marginal utility from increased loyalty by not raising taxes (Mueller, 2008). Selective use is one way to strategically employ the instruments of loyalty and repression (Wintrobe, 1998). The authoritarian leaders can try to gain the loyalty of those individuals that account most for the success of the regime. In turn, they may repress those groups that do not contribute to the regime's survival.

Obviously, authoritarian regimes and democratic parties face a very similar challenge. Both are trying to win "majorities". But in the case of the authoritarian

[2] One extreme example of control is the ideology of Calvinism (Bernholz, 1997).

[3] Examples for the "consumption" of authoritarian regimes can be found in Tullock (1987).

regime, it is considerably difficult to know which groups are most loyal and which ones can easily be repressed. This means the regime does not always know who belongs to the opposition since this group faces a disincentive - namely repression - to uncover. As a consequence, the authoritarian regime lives in uncertainty distinguishing between friends and enemies. This is a dilemma and the regime needs to deal with it (Wintrobe, 1998). All groups have an incentive to simulate support even if they are actually working against the regime. Thus, the authoritarian regime need to reassure which groups is on its side and which one is not.

Translating this dilemma to rational choice theory, the authoritarian regime has to deal with the difficulty of credibly receiving signals of trust and support by parts of the citizens (Wintrobe, 1998). In order to avoid costs that are attached to the reassurance process, the authoritarian regime may be reluctant to repress its citizens too much. In case the regime uses repression excessively, the information about true supporters is getting worse because the disincentive for opposition to uncover increases. Therefore, state-run "[t]errorist methods are a sign of weakness rather than of strength" (Cobban, 1971).

One way of solving this dilemma is ideology. It allows the regime to identify winners and losers of governmental policy. Communism for instance is one possibility to solve the dilemma by differentiating among the citizens by economic interest. Wintrobe (1998) also mentions other features to approach the signaling problem. Often, a "free-rider" option does not exist; instead political participation is rewarded by the government. Furthermore, party membership can be seen as an exclusive privilege.

Rent distribution, however, is the most important instrument. The easiest way of distributing rents is to create shortages in the first place. In return, fixing shortages creates rents for the authoritarian regime. These rents can be used for the own consumption or for distribution among the supporters.

To sum up, from a public choice perspective, it is assumed that authoritarian regimes have three principle goals: consumption, power and security. As a principle condition security - in the sense of security to maintain power - is pursued. One way to secure power is to redistribute income. Throughout the next subsection, we draw the line between energy policy and income.

2.2 Application to Energy Policy

Despite the fact that human rights violation, persecution - and other actions directing that way - are important tools to repress parts of the society, at this point, we concentrate on the role of energy policy. How do the goals of consumption, power and security affect energy policy? To put it the other way round, how can energy policy be used to reach these goals?

It is not the aim of the paper to analyze tax policy, hence, we consider tax rates to be given. Instead we focus on the influence of energy policy on income. Therefore, we assume income Y as a function of $Y(G, E)$ with $\partial Y/\partial E > 0$ and $\partial^2 Y/\partial E^2 < 0$. G stands for the amount of public goods and E as the amount of energy.

Energy is a rather general expression. In our analysis, it falls into primary energy and secondary energy. Resources such as coal, natural gas and oil belong to the group of primary energy. Electricity and heat are examples for secondary energy because they are generated from primary sources. In our case, both types are important. For that reason, we will discuss primary and secondary energy im more detail throughout sections 3.1 and 3.2, respectively. Another option would be to assume the supply of energy having the character of a public good which is provided by state-owned monopolists. In both cases, better energy supply increases the overall amount of public goods and this increases income Y.[4]

Reliable energy supply boosts economic growth and income. Following Toman and Jemelkova (2003) this is what drives the causal relation:

- Lighting enhances labor productivity.
- Reliable energy supply augments the capital stock, allowing capital to be used more effectively.
- Reduction of communication and transportation costs.
- Reallocation of time from energy production to income generation and education.

According to these aspects, reliable energy supply contributes to economic growth. Authoritarian regimes can use energy policy to foster economic growth by constructing and maintaining a secure, efficient, and affordable energy infrastructure. In turn, the regime can win the loyalty of parts of the population that have not had access to these goods before. Wintrobe (1998) even notes that due to the necessary redistribution of income for securing the regime security, the levels of redistribution are higher than in democracies. The other way round, the exclusion from energy supply can be used as a tool of repression. Moreover, the regime can repress parts of the society by letting them bear the burdens of constructing and maintaining power plants.

Since the authoritarian regime reserves parts of the income satisfying its own demand, the remaining income for society is smaller than it would be without the rent-seeking regime. Hence the leaders try to balance the losses for society (and for their supporters) by other means. One possible solution is the externalization of costs as mentioned in section 2.1.

[4] Toman and Jemelkova (2003) postulate a similar relation between income and energy.

While energy supply comes with various advantages, some indisputable costs appear as well. To be more precise, this group of external cost contains pollution, negative effects on biosphere and diversity, reallocation of people, expropriation, and the like. While it is extremely difficult for democratic governments to find a broadly accepted solution to these problems, authoritarian regimes can use the politically motivated distribution of external costs to repress or reward groups according to their loyalty towards the regime.

To sum up, in authoritarian systems, the total welfare for society is lower than in theoretical pure capitalist societies because the ruling class extracts rents from the public and distorts incentives for productivity. In order to balance these losses for society, an authoritarian regime can externalize energy plant construction and maintaining costs to the population and the environment. At the same time, it can reward favored groups with enhanced energy supply and increased economic performance.

2.3 Hypotheses

Summing up on what has been put forward in the subsections above, it can be said that authoritarian regimes seek to control the production of public goods, such as energy supply. They need to control the production and/or distribution processes in order to be capable to repress and reward certain groups of society. The most direct way of controlling a utility is owning it. Therefore, our first hypothesis claims that

- Authoritarian regimes use NOCs to gain greater control over - and profits from - domestically available oil and gas resources.

Our theoretical assumptions above also proposed that authoritarian regimes are rational actors that strive to minimize costs of production of the desired good as well as the costs of control. Since economic costs of building and maintaining a plant are rather fixed, the authoritarian regime needs turn to soft costs instead. Therefore, our second hypothesis claims that

- Authoritarian regimes care less about costs that can be externalized to society and the environment. As a consequence, power plants can be constructed in a faster and in a cheaper way.

The costs of control are lower if there are only a few decisive producers and distributors to be controlled. In turn, a de-centralized and autonomous production parks and grids increase the necessary effort to keep the grip on the system. Therefore, the third hypothesis claims that

- In authoritarian states, energy production is more concentrated than in democratic countries.

By discussing the state of supply security, section 3.2 also defines indicators on the third hypothesis. Section 4 is committed to evaluate policies adopted to foster supply security. It also proves the second hypothesis by describing how costs are externalized in constructing large-scale plants. Section 4.2 gives an insight in NOCs and therefore the first hypothesis. In the end, section 5 validates and falsificates the hypotheses.

2.4 Design

Since our hypotheses draw on the theory of authoritarian regimes, the central cases need to be states that are considered to be governed by such a regime. China and Russia belong to this group since the Freedom House Index (2010) (FHI) ranks them as "non-free". In the 1 to 7 point ranking[5] Russia scores 5.5 points and falls in a group with Rwanda, Qatar and others. China (6.5) comes behind and is grouped with Belarus and Cuba for instance. As has been shown in section 1, India and Brazil nicely fit to China and Russia with regard to the economic development and energy economic situation. Both are democracies, therefore, they receive the FHI-label "free". We use Brazil and India to control the findings on China and Russia. Since the latter ones are ruled by authoritarian regimes and the basic conditions are more or less similar, we draw back differences in energy policy (dependent variable) on the type of governance (independent variable). This procedure of fixing conditions while testing different outcomes for one independent variable is commonly called Most Similar Case Design (MSCD) (Lauth et al., 2009).[6]

Energy policy in the BRIC countries is worth examining because of the major role BRIC countries are playing in setting global environmental, energy, security, and economic policy. However, energy policy in BRIC countries is even more crucial to understand as other developing countries attempt to emulate the process of economic emergence the BRICs have undertaken. Disentangling the "good" and "bad" governance approaches in the four BRIC countries as it relates to energy policy will improve understanding of the options available to the other developing countries as they begin to face even larger challenges managing their own natural energy resources and energy imports, and satisfying the demand for energy services among their own richer populations.

[5] The value "1" stands for free countries. The least free of the worst dictatorships receive a "7" and the label "non-free"(Freedom House, 2010).

[6] South Africa, Mexico, Turkey and other rapidly emerging democratic economies also qualify for the Brazil and India group. Respecting scale and scope of this article, however, we decided to restrict to four cases and conduct our research in depth instead.

3 Energy Economic State of Supply Security

The section above has given information about this paper's aim and scope. It is now time to turn to the core analysis. In the following, we will thoroughly discuss how "security of supply" can be translated from a rather theoretical goal to empirical reality. Therefore, we split the generic term into parts.

Primary energy supply security is what is commonly referred to as the ability of the domestic supply side to meet current and short to medium-run expected energy demand. In case the domestic energy production does not equal the required amount of energy demanded by domestic consumers such as the industry and private households, international trade balances the difference. In the reverse case, in countries where energy supply is greater than energy demand, energy resources can be exported to foreign customers or left in reserves for future consumption. Importing energy resources increases the risk of domestic energy supply security because the availability of international trade partners inherently uncertainty. To illustrate this point, the power politics played on the back of oil price shocks by the Organization of the Petroleum Exporting Countries (OPEC) can negatively impact energy-intensive industries.

Electricity delivery and energy reliability is another piece of the energy security puzzle. In order to guarantee the delivery of primary energy such as oil and gas to power stations, pipelines need to be built and maintained. Additionally, electricity requires investment in network infrastructure since electric grids transmit power from power plants to end-users. Rural development relies on investment in energy and electricity infrastructure. Private operators, quasi-private operators and state-owned operators secure the transmission and distribution of energy and power to both urban and rural areas. However, with all physical resource infrastructure systems, it is pivotal to avoid bottle-necks, leakage in transit, or drops in quality (e.g. voltage) in order to maintain network security.

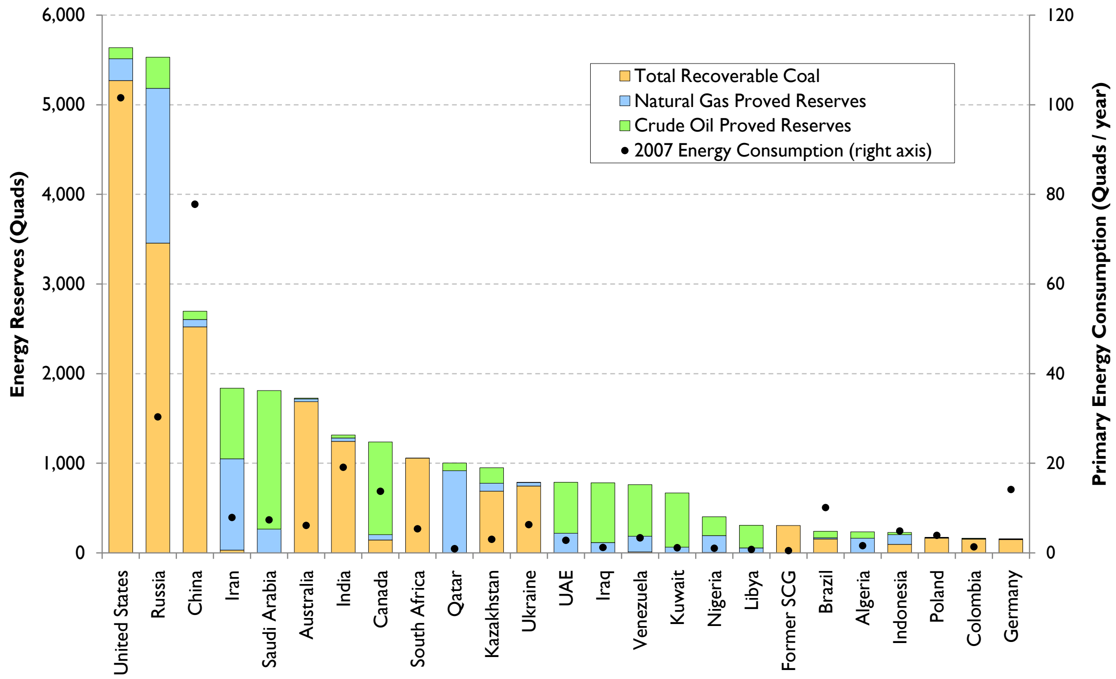
The following subsections 3.1 and 3.2 focus on examining to what extend security of supply has been achieved in the BRIC states. First, indicators are developed and detailed. Second, a way of quantifying these indicators is provided. Finally, the subchapters offer empirical results. The purpose of the radar-charts at this section's end (3.3), is to illustrate the state of supply security graphically. Afterwards, section 4 concentrates on energy policies of the BRIC governments to meet their respective challenges.

3.1 Domestically Available Resources

In this section, we examine the current energy mixes of the BRIC countries, the role of international energy trade, and the resource bases of both fossil fuels and renewable energy. The BRIC countries face a wide range of challenges with respect to managing and securing their access to energy resources. And in the evolution of their energy systems, each BRIC country's effort to secure its supply of energy has been greatly shaped by its natural resource endowments.

By primary energy consumption, the BRIC countries are among the largest nine in the world and are the four largest among non-OECD members. In 2009, the BRIC countries were among the 6 largest consumers of oil, the 23 largest consumers of coal, and the 20 largest consumers of natural gas. In terms of total fossil energy reserves, on an energy content basis, the BRIC countries are among the top 20. The BRIC countries' coal reserves are among the largest 11, their oil reserves are among the 21 largest, and their natural gas reserves are among the 35 largest (US Energy Information Administration 2010c). Figure 3 shows the reserves by type of fossil resource for the countries with the largest fossil resources in the world. Recent annual consumption is also shown for comparison.

Figure 3: Energy Reserves by Resource Type with 2007 Energy Consumption



Source: U.S. Energy Information Administration (2010c).

3.1.1 China

Energy from coal dominates China's energy consumption mix. In 2008, 70% of Chinese energy consumption came from coal while oil supplied an additional 20%. Hydroelectric generation supplied 6% of Chinese energy consumption and natural gas, nuclear and renewables contributed less than 3% each to total energy consumption. Chinese coal reserves were the third-largest in the world at 126 billion short tons in 2005, behind the United States (264 billion short tons) and Russia (173 billion short tons). At 3.2 billion tons, China produced 44% of the world's coal in 2009, making it the world's largest producer of coal, 3 times larger than the second-largest producer, the United States. At its 2009 coal production rate, China's coal reserves will deplete in 39 years. Of the 10 largest coal producers in 2009, only Indonesia would deplete its reserves faster than China if production rates stayed constant. In all likelihood substantial new resources will be added to Chinese coal reserves, while coal imports from Indonesia, Australia, Vietnam, Mongolia and Russia continue to grow. Since 2002, China has significantly increased its coal imports: from 2002 to 2008, Chinese coal imports grew over 400%. Nevertheless, coal imports still made up only 3.8% of total coal consumption in China in 2009 (US Energy Information Administration 2010a).

Since 1993, China has been a net importer of oil as oil consumption has grown faster than domestic oil production. China's net oil import rate was 3.5 million barrels/day in 2008 – 50% of its total consumption – making it the world's 3rd largest net importer of oil behind the United States (9.8 million barrels/day) and Japan (4.0 million barrels/day). The largest oil exporters to China are Saudi Arabia (725 thousand barrels/day), Angola (596 thousand barrels/day), and Iran (425 thousand barrels/day) (US Energy Information Administration 2010a). The depletion of older onshore wells in China is leading to growing attention to offshore oil resources, some of which are in disputed ocean territories (French, 2005), as well as onshore resources deeper in western China. Natural gas does not currently play a significant role in the Chinese economy, but the lower emission profile of natural gas power plants relative to coal-fired plants, may lead to an expansion of natural gas in China in the near future. Gas pipelines from Eastern Siberia into China are likely to move forward (BBC News, 2006) as China seeks to simultaneously increase development of domestic, including offshore, natural gas resources.

China doubled its wind capacity in 2009 to nearly 26 GW, giving it the second largest installed capacity in the world behind the United States. While wind currently only supplies less than half of one percent of China's electricity, the wind on-shore resources available in China are enough to generate 24.7 PWh, greater than seven times current Chinese electricity consumption. Relative to prevailing contract prices, the on-shore wind resource in China could still provide more than twice current electricity consumption. China also has a substantial offshore wind resource base, particularly in South China in the Straight of Taiwan. China's best solar resources are concentrated in the west, near China's borders with India and Nepal (McElroy et al., 2009).

3.1.2 India

Like China, India uses coal to provide a majority of its energy. 53% of Indian energy demand was met with coal in 2006 while oil provided an additional 31%. Natural gas, hydroelectric and a small share of nuclear made up the balance. In 2007, 8.7% (net of exports) of Indian coal consumption was imported.

India's domestic oil production has been nearly constant since 1990 while oil consumption has grown nearly three-fold in the same time period. By 2008, India was the 5th largest consumer of oil at 2.8 million barrels/day and the 4th largest net importer of oil with over 2.5 million barrels/day in net imports. The largest oil importers to India are Saudi Arabia (644 thousand barrels/day), Iran (476 thousand barrels/day), Nigeria (308 thousand barrels/day), and Iraq (280 thousand barrels/day) (U.S. Energy Information Administration, 2010c).

As in China, natural gas demand is expected to grow in India as the detrimental effects of pollution from coal power plants increase and as major domestic gas plays go into production. When it is complete, the 3,500 MW power plant at Dadri, Uttar-Pradesh will be the largest natural gas-fired plant in the world. Since 2004, India has been a net importer of natural gas, utilizing significant quantities of liquefied natural gas (254 Bcf in 2006) while also seeking to expand its pipeline connections to other countries, such as Iran (US Energy Information U.S. Energy Information Administration, 2010c).

3.1.3 Brazil

Unlike China and India, Brazil does not rely heavily on coal for electricity generation. Instead, 85% of Brazil's electricity comes from hydroelectric dams. Natural gas, coal, nuclear, and renewables make up the balance. For liquid fuels, Brazil consumed 2.5 million barrels/day of petroleum in 2008; however, all gasoline sold in Brazil is blended with ethanol. In 2008, Brazil produced 454 thousand boe/day of ethanol and 20 thousand boe/day of biodiesel. Currently, Brazil consumes more oil than it produces. However, because of significant biofuel production, combined with large offshore petroleum resource discoveries in the past three years, Brazilian oil production is expected to continue growing faster than its oil consumption.

Brazil has the smallest proved reserves of fossil energy among the BRIC countries. However, the pre-salt fields off near the coast of Rio de Janeiro, discovered in 2007, could dramatically shift Brazil's oil reserve status. While the Brazilian pre-salt fields are still being explored, by some estimates, the size of this resource could put Brazilian reserves on par with the countries with the five largest oil reserves in the world (Wheatley, 2010).

3.1.4 Russia

Russia has the largest fossil energy reserves of the BRIC countries on an energy content basis and the second largest fossil energy reserves in the world behind the United States. Russia's economy is strongly dependent on energy exports. Over one-fifth of the country's GDP is derived from its oil and gas industry. At 183 billion cubic meters, Russia is the largest natural gas exporter in the world, 85% larger than the world's second largest gas exporter, Norway. 96% of Russian gas exports are transported via pipeline to Europe. Almost all of the remaining 4% of Russian gas exports are exported as liquefied natural gas (LNG) to Asia (BP Stat Review).

Russia's natural gas reserves are the world's largest: nearly 70% larger than Iran's, the second largest. 27% of all proven gas reserves in the world and 53% of all non-OPEC gas reserves are in Russia. At 2009 production rates, assuming no reserve increases, Russian gas reserves would deplete in 84 years, longer than the global average of 63 years and the North American average of just 11 years. Domestically, natural gas provided 55% of Russia's energy consumption in 2005. Russia's coal reserves are the world's second largest, yet only 16% of Russia's domestic energy consumption was derived from coal in 2005. Russia's oil reserves are the world's eighth largest.

3.2 De-concentration and Development

Above, we overviewed the state of diversification of energy production as well as domestically available resources. In the following, we complete the picture of supply security by focusing on degrees of de-concentration (3.2.1) and de-centralization (3.2.2) of energy production parks. Additionally, we discuss how both characteristics can be used to support rural development (3.2.3 and 3.2.4). However, increasing urbanization of the population, which increases urban energy demand, puts constraints on both ideas.

3.2.1 De-concentration

De-concentration of the supply side means to share the total amount of production among a larger number of producers. The security advantage of de-concentration lies in the fact that a polypolistic generation park can mitigate the loss of a small share much better while a highly concentrated situation can hardly cope with the shortage caused by the failure of a big producer. Just consider the case of taking a nuclear station temporally off the grid because of an incident. The concentrated case of having some big plants supplying the big share of electricity reacts with a rise in prices or additional import.

Taken by the average plant size, China has the largest plants among the BRICs. It is followed by Russia. Brazil comes third while India's production park is four times more de-concentrated than the Chinese one. The Herfindahl-Hirschman-Index (Hirschman, 1964), a common economic index to quantify concentration, offers an alternative scenario. The HHI estimates the degree of concentration by aggregating the quadratic sizes a^2 of each plant i. The result ranges between 0 (atomically de-concentrated) and 10,000 (1 plant only).

$$HHI = \sum_{i=1}^{N} a_i^2 \quad with\ a_i = 100 * \frac{x_i}{\sum_{j=1}^{N} x_j} \tag{4}$$

While having the largest plants by average size, China's production park is least concentrated if measured by the HHI. Russia shows the same phenomenon. The high concentration rate in Brazil falls back on the large production share of the Itaipú Dam. India as well is relatively de-concentrated in terms of the HHI.

Table 3: Concentration Indicators

	Brazil	Russia	India	China
Average plant electricity generation (MWh)	669,817	1,358,044	466,916	1,919,078
HHI of all power plants by their output	344	95	100	26
Number of plants	643	660	1541	1,701
Aggregated electricity generation (MWh)	430.692.291	896.308.902	719.518.179	3.264.351.803

Time: 2007
Source: own calculation on the base of CARMA (2010).

Our third hypothesis claimed that authoritarian system fall back on concentration measures in order to secure control over the supply system. This hypothesis is partly correct only. As our data show, Russia and China have the largest plants by the average output size. These countries, however, also show up with the relatively lowest level of concentration (HHI) among the BRICs. Our hypothesis seems to be falsified. Nonetheless, it is worth examining how results change by replacing output concentration measures by geographical concentration measures. This is the next subsection's aim.

3.2.2 De-centralization

The term de-centralization stands for de-concentration from a geographical perspective. The security advantage is two-fold. First, if many producers are centralized at one place, the shortage caused by a geographically concentrated incident is bigger than in the de-centralized scenario. Second, the BRIC states have in common that they belong to the geographically largest countries on earth. Placing solar panels or wind turbines throughout the country uses the fact that solar radiation moves during the day. Also the wind blows at different places. While one part of the country faces sunset or changing winds, another may offer just the right intensity or speed, respectively. Therefore, de-centralization makes the supply side less vulnerable to geographically focused earthly and human shocks and uses the country's large size to hedge changing gradients of wind, sun and water.

Urbanization, however, requires power generation to be available at places where many people life. Therefore, the degree of de-centralization is limited by the degree of urbanization. In order to integrate both aspects, the following quantifications of regional electricity generation are always divided through regional population or regional GDP.

The quantification goes two ways. On the one hand, we calculated each region's electricity generation-to-population ratio. With regard to this indicator, Russia is the country with the highest de-centralizations degree. We derive this information from the variance and standard deviation of the regional generation-to-population ratio among the BRICs. Case in point, Khakass, a federal subject in the South of Siberia, produces more than 2300 time as much electricity per person than Kalmykia at the Caspian Sea. Russia is followed by Brazil and China. India's production park is relatively de-centralized, instead.

Table 4: Centralization Indicators 1

Regional Electricity Generation to Regional Population Ratio				
	Brazil	Russia	India	China
Lowest (MWh/p)	0.01	0.02	0.02	0.93
Highest (MWh/p)	9.75	7.73	1.82	47.39
Average (MWh/p)	2.00	6.77	0.62	2.75
Variance $(MWh/p)^2$	4.93	57.25	0.22	2.64
Standard Variance (MWh/p)	2.22	7.57	0.47	1.62

Time: 2007
Source: own calculation on the base of CARMA (2010).

On the other hand, we calculated the variances and standard deviations of the regional electricity generation-to-GDP ratio. The picture slightly changes. Russia, however, still shows the highest geographical concentration of electricity generation per GDP. This time, India comes second. Following up, Brazil and China are pretty close to each other. Remarkably, the generation-to-GDP ratio proves the decentralization degree of India to be lower than the one from the generation-to-population degree. The reason may be an industrial one. While people in rural areas make their living from agriculture business, the energy-intensive industries of the Indian State of Uttar Pradesh, for example, require the generation of more electricity.

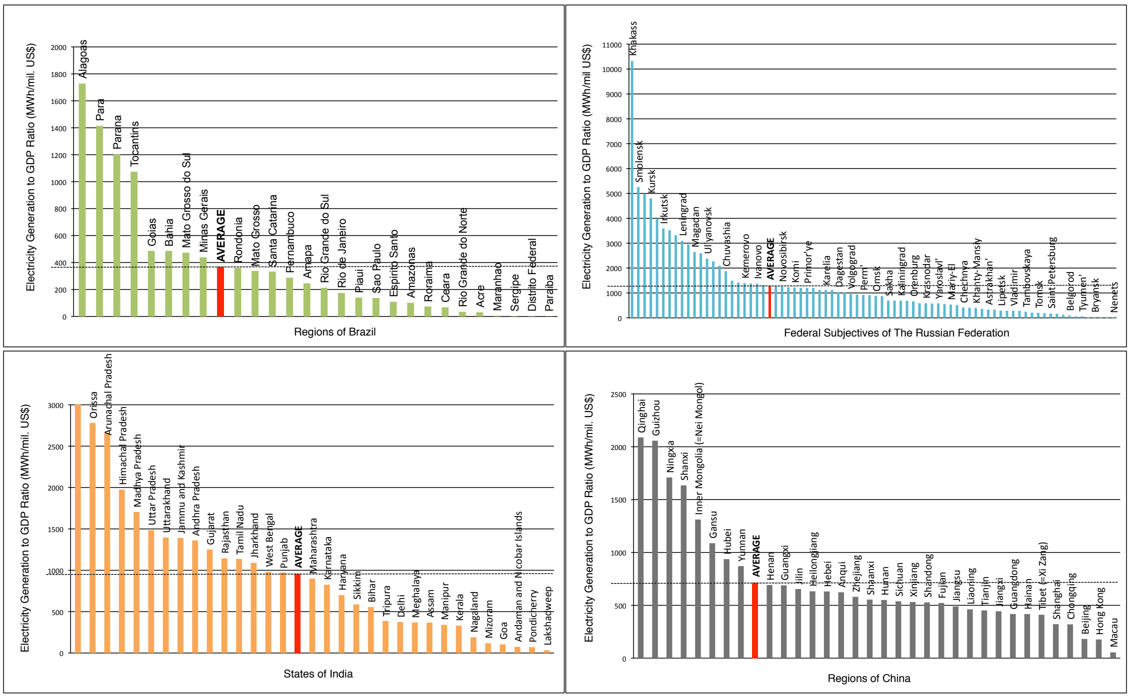
Table 5: Centralization Indicators 2

Regional Electricity Generation to Regional GDP Ratio				
	Brazil	Russia	India	China
Lowest ($MWh/mil.US\$$)	1.75	7.77	33.50	54.84
Highest ($MWh/mil.US\$$)	1,728	10,328	3,054	2,088
Average ($MWh/mil.US\$$)	369	1.297	960	714
Variance ($MWh/mil.US\$)^2$	209,424	2,561,285	650,449	255,434
Standard Variance ($MWh/mil.US\$$)	458	1,600	807	505

Time: 2007
Source: own calculation on the base of CARMA (2010).

The following charts 4 precisely depict how much electricity is generated per GDP in each of the regions. Russia's highly centralized production park is eye-catching.

Figure 4: Regional Electricity Generation to GDP Ratios



Source: Own calculation on the base of CARMA (2010).

Let us turn to our third hypothesis again. While subsection 3.2.1 rejected the hypothesis, this subsection verifies our assumption. Both measures - the generation-to-population ratio and the generation-to-GDP ratio - approve that Russia's production park is relatively centralized. One reason is that the country's rich fossil resources are concentrated in Siberia. The other BRICs change places in the ranking due to different quantifications. In general, large-scale projects, such as the Belo Monte in Brazil or the Three Gorges Dam in China shift the production park towards centralization, of course.

3.2.3 Advantages of Small Scale Projects vs. Economies of Scale

Tackling rural underdevelopment, de-centralization and de-concentration are interlinked with each other. The reason is that building small-scale plants (de-concentration) in villages (de-centralization) support rural electrification that is a stepping-stone of rural economic development.

According to Shih and Wirtshafter (1990), small plants provide several advantages over large plants with regard to rural development. First, small size plants can be operated and maintained by local authorities. These lower federal levels are able to finance and secure the equipment, to command the construction, and to control the outcome. The latter means they can profit by taxing the outcome. Therefore, small-scale projects can provide income for local authorities. In turn; this input can foster rural economic development and political independence from the federal state.

Second, large-scale projects require large-scale upfront investment and supervision at a higher level in the federal system. Especially when it comes to negotiations, large-scale investors do barely meet with local authorities, but in eye-level with state policymakers. Third, small hydro plants, for example, often substitute small coal-fired plants in rural areas. Therefore they reduce carbon dioxide emissions, which is obviously an environmental advantage. Fourth, the construction design of small plants is often standardized. Having many similar plants, therefore, shortens the process of constructing a station. Large-scale construction usually requires more time and capital than expected (Reuters, 2009). Small-scale projects instead are quickly built and the spread of innovation moves faster among the small (Shih and Wirtshafter, 1990).

Excluding these impacts on rural development, large-scale projects benefit from economies of scale effects. This means they provide cheaper investment-to-output ratios. In subsection 4.1.3, we discuss what kind of social, political and environmental costs are attached to large-scale projects.

Coming back to our finding in subsection 3.2.1 and 3.2.2, Russia does not seem to use the advantages of small-scale projects. China as well exploits the economies of scale effects. Besides this calculation, access to electricity is not as poorly developed as in India. Therefore, India has an incentive to use the advantages of small-scale energy production. The following paragraphs will evaluate to what extent the populations of the BRIC states have gained access to electricity.

3.2.4 Electricity Generation and Energy Delivery in Rural Areas

In its World Energy Outlook 2004, the IEA first published data on the so-called Energy Development Index (EDI)[7]. In 2007, the IEA integrated India's and China's

[7] "To construct the EDI, a separate index was created for each indicator, using the actual maximum and minimum values for the countries covered. Performance is expressed as a value between

regions to the data set. Reviewing around 100 emerging economies, the Human Development Index (HDI) seems to be linked positively to the EDI. For our cases, this means that further development may also stimulate access to energy and vice versa. From a static point, the EDI ranks Brazil and China above India in 2007. Russia is not part of the sample.

Table 6: Energy Development Index

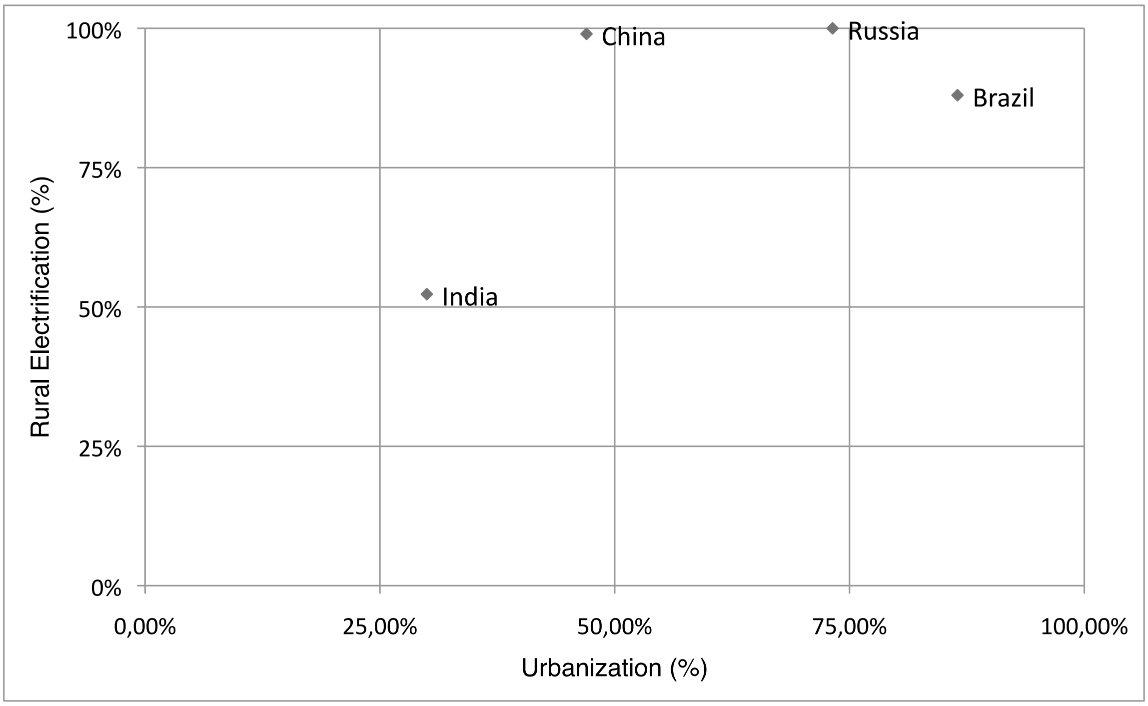
	Brazil	Russia	India	China
Clean cooking fuel index (%)	0.874	NA	0.265	0.602
Electricity access index (%)	0.951	NA	0.519	1.000
Electricity generation per capita index (%)	0.383	NA	0.102	0.306
Energy Development Index	0.736	NA	0.295	0.636

Time: 2007
Source: International Energy Agency (2007).

While the EDI nicely illustrates performances at the aggregated country level, henceforward, we make a difference between rural and urban development. Doing so, the state of energy delivery becomes more precise. The next figure 5 and the table 7 below show India being in the most striking position. By far, the country has the lowest urbanization rate which means that the majority of the people life in rural areas.

0 and 1, calculated using the following formula: Dimension index = (actual value − minimum value)/(maximum value − minimum value). The index is then calculated as the arithmetic average of the three values for each country" (International Energy Agency, 2007).

Figure 5: Urbanization vs. Rural Development



Time: 2010
Source: U.S. Energy Information Administration (2010d); UN Population Division (2010).

Table 7: Urbanization Indicators

	Brazil	Russia	India	China
Rural population (thousands)	26,326	37,665	850,005	718,307
Urban population (thousands)	169,098	102,702	364,459	635,839
Urban population (%)	87	73	30	47
Rural annual growth rate (%, 2010-2015)	-1.98	-7.40	0.78	-1.01
Urban annual growth rate (%, 2010-2015)	1.14	-2.00	2.38	2.29
Population living in cities >10mil. (%)	19	10	16	5
Population living in cities 5-10mil. (%)	3	0	9	8
Population living in cities 1-5mil. (%)	25	15	17	25

Time: 2010
Source: UN Population Division (2010).

As can be seen in table 8, more than 50% - or 404 million people - live without access to electricity in India. Russia meets OECD like electrification standards while Brazil and China have not achieved full coverage yet.

Table 8: Access to Electricity

	Brazil	Russia	India	China
Total (%)	98	100	65	99
Urban (%)	100	100	93	100
Rural (%)	88	100	52	99
Population without electricity access (mil.)	1.1	0.0	404.5	8.0

Time: 2008
Source: U.S. Energy Information Administration (2010d).

India's poor performance is mirrored by the rural poverty rate, as can be seen in table 9. China, repeatedly, shows up the relatively best state of rural development.

Table 9: National Poverty Rate

	Brazil	Russia	India	China
Total (%)	17	31	29	5
Urban (%)	13	NA	25	<2
Rural (%)	33	NA	30	5

Time: 2008
Source: World Resource Institute (2009).

As Kelli (2010) points out, India's lack of decent energy supply and the generally underdeveloped rural areas result in the emergence of a private energy production system that runs side-by-side with the public system. Increasingly, companies rely on their own captive power generation instead of the expensive and bureaucratic state-run energy delivery. Recent legislation allows captive producers to use the public grid for energy delivery. This "open access clause" may boost further investment in private installation (Kelli, 2010).

To sum up, India still has a long way to go. China and Russia do increasingly well. In Brazil rural poverty is a major problem (32.6% of rural population lives in poverty). Access to electricity, however, is widely available.

3.3 Radar charts

Figure 6 nicely illustrates the BRIC states' performances by applying radar-charts (Borgelt and Kruse, 2002). First, six indicators (see table 10) have been standardized.

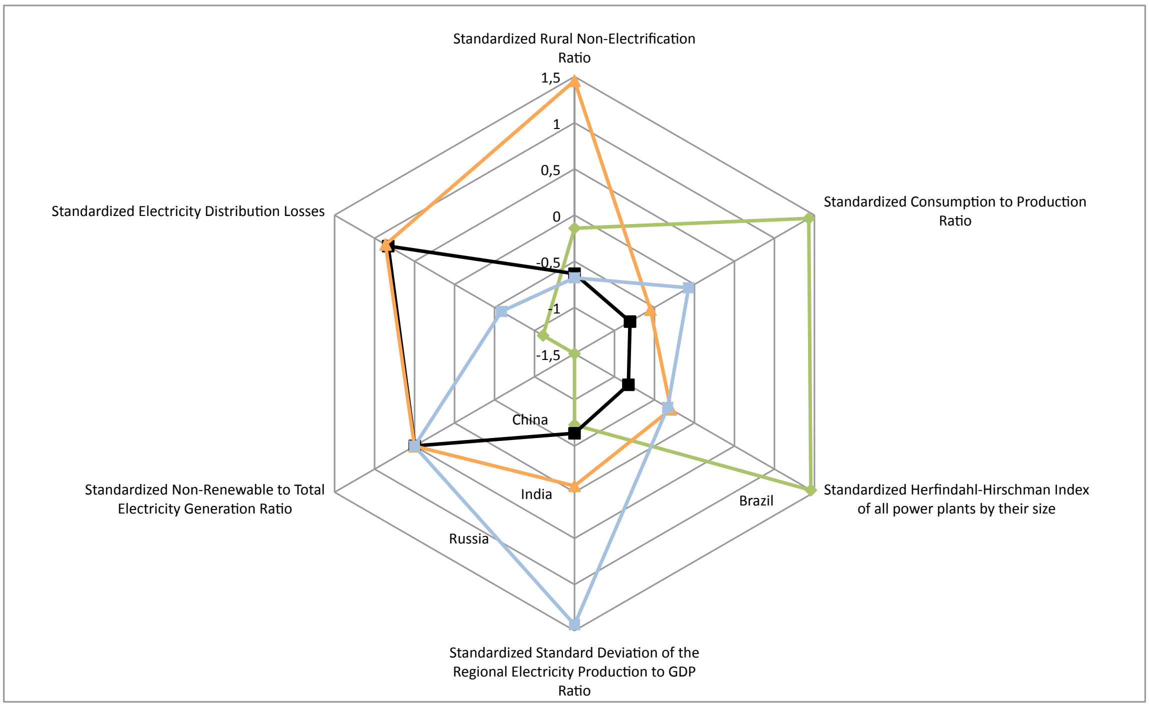
Table 10: Radar Chart Data

	Brazil	Russia	India	China
Rural Non-Electrification Ratio	-0.14	-0.68	1.45	-0.63
Energy Consumption to Production Ratio	1.43	-0.07	-0.55	-0.81
HHI of all power plants by their output	1.46	-0.33	-0.29	-0.83
Standard Deviation of the Regional Electricity Generation to GDP Ratio	-0.73	1.43	-0.07	-0.64
Non-Renewable to Total Electricity Generation Ratio	-1.50	0.50	0.50	0.50
Electricity Distribution Losses	-1.11	-0.59	0.86	0.83

Time: 2007; standardized values.

Second, the values are drawn onto a multi-axis graph. The resulting country-specific positions are connected. And the connected dots create a field, the so-called SMOP-field (Schmid and Förster, 2009).

Figure 6: Radar Chart



With regard to absolute results, the explanatory value is very limited of course. The purpose of comparing case performances, however, is easily achieved. Since small fields equal a relatively good performance: China, the supposedly most authoritarian system, scores best among the BRICs.

4 Policies to Foster Supply Security

The forthcoming section adds up to last section's findings and asks what policy makers are actually doing to foster security of supply. Subsection 4.1 is committed to depicting renewable energy policies in general and hydropower projects in particular. Subsection 4.2 outlines the relationship between big oil producers and the government. Of course, a lot more issues are of interest, e.g. the solar branch and the nuclear industry. Since space is limited, however, further research will need to focus on these themes.

4.1 Hydropower and Renewable Energy Policy

One aspect of securing the supply of power is to diversify the production portfolio. In order to do so, the BRIC states intensify their efforts of attracting investment in hydroelectric power plant systems. Hydropower production is flexible in scale and in meeting different kinds of demand. Hydro storage and pump station can meet peak-load demand, while run-of-river plants provide base-load capacity (International Hydropower Association, 2007). Therefore, the hydropower production park can be diversified itself. Hydropower is one of the oldest commercially scalable renewable energy sources, having been deployed around the world for hundreds of years, while other renewable sources such as photovoltaics, geothermal and wind energy, were developed more recently only. As can be reviewed in table 11, the installed capacity is expanding and there is still huge economically exploitable potential in each of the BRICs as the economically explotable capability proves.

Table 11: Hydropower Capacity

	Brazil	Russia	India	China
In place (GW)	13.30	45.70	32.00	145.00
Under construction (GW)	5.50	7.00	7.00	80.00
Construction to installed capacity ratio (%)	41.35	15.32	21.88	55.17
Planned (GW)	33.00	8.00	9.00	NA
Planned to installed and under construction capacity ratio (%)	175.53	15.18	23.08	NA
Economically exploitable capability (TWh/yr)	3,000	852	660	1,753

Time: 2007
Source: International Energy Agency (2009); World Energy Council (2007); World Energy Council (2009).

Brazil is the front-runner in hydropower development. Especially by completing the Itaipú Dam, it massively increased its energy production and electricity generation from hydropower.

Table 12: Hydroelectric Power

	Brazil	Russia	India	China
Hydro energy to total energy production ratio (%)	14	2	2	2
Hydro electricity to total electricity generation ratio (%)	84	18	15	15

Time: 2007
Source: International Energy Agency (2010).

4.1.1 Benefits of Hydroelectric Systems

Although it is an essential benefit, hydropower comes with a lot more advantages than securing the energy supply only.[8] First, generating power from hydroelectric power plants can be a very profitable business. And since there are economies of scale at work, the benefit of running a dam progressively increases with its output capacity. The BRIC states have already found out that their massive rivers (e.g. the Paraná in Brazil, the Volga in Russia, the Ganges in India, and the Yangtze in China) bear the potential to do good in various ways.

Second, from an economic development perspective, cheap and reliable energy is a necessity to attract foreign direct investment (FDI) in manufacturing and other energy-intensive sectors. Even when wages are climbing, cheap and reliable energy enhances competitiveness (The Economist, 2010c). Table 13 shows that a large share of China and Russia's GDP is made by the energy-intensive secondary sector. In India and Brazil, the industrial economy accounts for less and the primary consumption of energy per Dollar of GDP is lower.

Table 13: Energy Intensity, FDI and Secondary Sector Indicators

	Brazil	Russia	India	China
Industrial sector share of GDP (%)	25.40	34.80	28.20	46.80
FDI to GDP ratio (%)	2.86	4.34	3.55	3.42
Energy intensity (Total Primary Energy Consumption per US $ of GDP (Btu per Year 2005 US $ (PPP)))	6,012	15,312	6,543	11,412

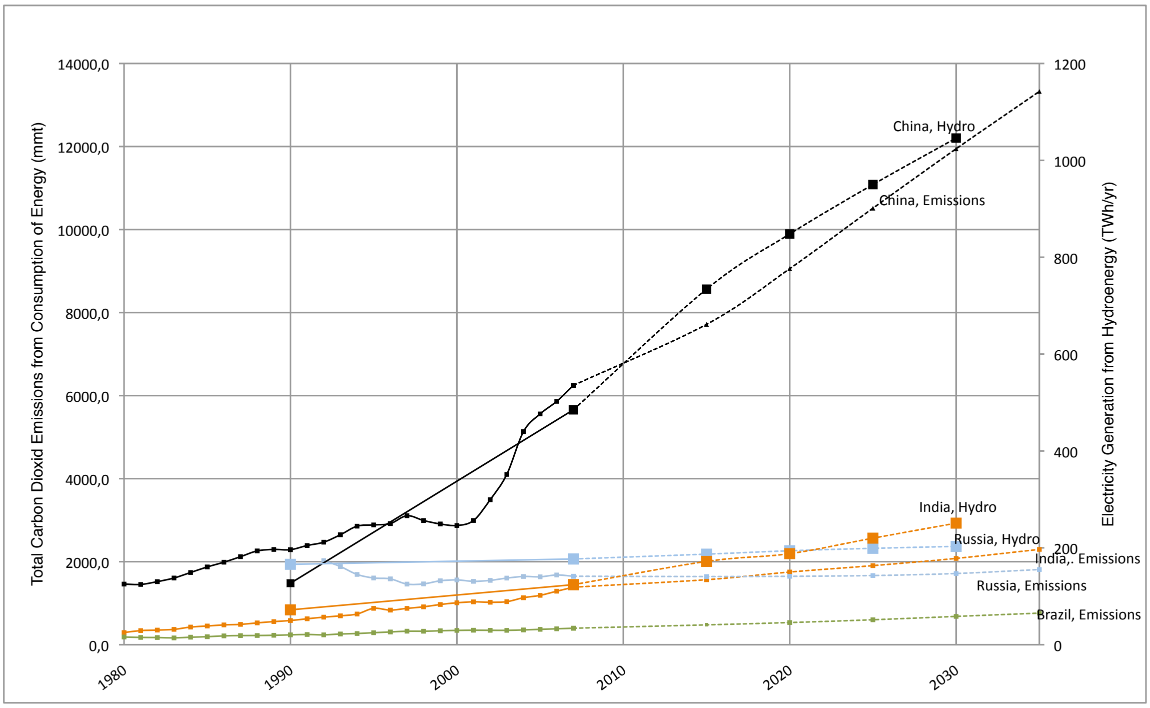
Time: 2007
Source: The World Bank (2010b); U.S. Energy Information Administration (2010c).

Third, the production of hydropower does not emit pollutants; therefore, hydro energy is a climate-neutral source. This environmental advantage also helps to

[8] Existing disadvantages are discussed in 4.1.3.

achieve politically defined mitigation targets.[9] Figure 7 illustrates the rapidly increasing carbon dioxide emissions. China is especially eye-catching due the size of total emissions. Without hydropower development, the emissions would grow even faster.

Figure 7: Carbon Dioxide Emissions and Hydropower Generation for 1980-2007 with Projection to 2035



Source: U.S. Energy Information Administration (2010b); U.S. Energy Information Administration (2010c); International Energy Agency (2009).

Finally, with regard to social consequences, hydropower can provide reliable supply of electricity to rural areas where electrification had been low before. In 2008, there were 404 million people in India without access to electricity. In rural areas, where only half of India's households (53%) are connected to the grid, hydropower can make a difference in people's life (International Energy Agency, 2009).

As has been argued in subsection 3.2.3, small hydropower supports rural development but large-scale plants incorporate economies of scale effects instead. In order to figure out which size of project is preferred in the BRIC countries, we are leaving the aggregated level for a moment and focus on single hydropower stations.

The Three Gorges Dam in China, when completed in 2011, will contribute 22.5 GW to the hydro capacity. And there are many more massive hydro dams under construction in China, such as the Xiluodu (12.6 GW) and the Xiangjiaba (6 GW) (World Energy Council, 2009). Brazil's Itaipú (14 GW) and the Belo Monte hy-

[9]Brazil and China ratified the Kyoto Protocol in 2002, India and Russia followed up in 2004. Besides these voluntary international agreement to reduce GHG emissions, China ratified its own "Renewable Law" which seeks to increase the renewable share in the national energy portfolio from 3% to 10% by 2020 (The World Bank, 2010a).

dropower station (11.2 GW) at the Xingu River also range among the largest dams in the world. India relies on many small hydroelectric plants instead of a few large ones. The Subansiri Lower is the biggest project under construction with a capacity of 2 GW. Four of the fifteen largest hydropower stations in the world are Russian. Boguchany (3 GW) is one of the current projects (World Energy Council, 2007; World Energy Council, 2009).

Obviously, the hydropower business thinks big in the BRIC states. Only India spreads the capacity to many small plants. Especially China and Brazil push forward the very big projects. By building stations such as the Three Gorges Dam, the operators benefit from economies of scale. However, there are all kinds of costs that are attached to the dams and increase with their size as well. We will figure out which costs occur, furthermore, how policymakers seek to reduce them.

4.1.2 Financing and Promoting Hydropower Projects

Hydro projects begin with immense up-front costs. Therefore, it is a question of finance whether or not policymakers succeed in their objective to move start capital to new hydroelectric systems.

The Clean-Development-Mechanism (CDM), a mechanism introduced by the internationally launched Kyoto Initiative, mobilizes investment in hydropower projects. At the end of December 2009, 27% of CDM projects were hydropower projects. Wind (14%) comes second. The top host countries are China, India and Brazil (International Hydropower Association, 2010).

Domestically, the countries also seek to attract investment from the private sector. With regard to the lending interest rate, for instance, state-run banking sectors in China and Russia provide cheaper investment capital than the partly private banking sectors in Brazil and India. It seems that policymakers of authoritarian regimes can command banks to give credit to politically desired projects. In China, especially, these projects tend to be large in scale. The regime's role in providing capital became eye-catching in China's recent attempt to rebound the financial crisis (The Economist, 2010b). This behavior strongly relates to what Wintrobe (1998) said in subsection 2.1 on the capability of authoritarian regimes to nationalize resources in case there is the political need to do so. This time, the required resource is capital to keep the large-scale projects running smoothly.

Table 14: CDM Projects

	Brazil	Russia	India	China
Number of CDM projects	35	0	58	354
Share of total CDM projects (%)	6.35	0.0	10.53	64.25
Lending interest rate	47.30 %	12.20 %	13.30 %	5.30 %

Time: 2009
Source: International Hydropower Association (2010).

Another structural characteristic of electricity markets is the public-private ownership ratio. To what extend is the state part of the production, transmission and distribution of power? Table 15 shows that the upstream part - electricity generation - is partly liberalized among the BRIC states. Very generally speaking, the production park falls in two parts, a private part and a slightly bigger state-run part. When it comes to the downstream phase, however, China and Russia sustain their grip on transmission and distribution while Brazil and India release their hands. This proves our theoretical assumptions to come close to reality. We claimed in subsection 2.3 that authoritarian regimes sustain a big public share of distributional systems in order to remain in position to reward and repress by providing and cutting public goods.

Table 15: Ownership

	Brazil	Russia	India	China
Electricity Generation	State-owned Eletrobras operates 60% of the production. The company holds 50% of the Itaipù Dam which provided 14.7% of Brazilian electricity generation in 2007. IPPs account for the remaining 40%.	By 2011, 14 territorial generation companies (TGK) will have replaced the state monopoly (RAO UES). Gazprom and UES (both state-run by a 50.01% share), however, signed long-term contracts and hold shares in the TGKs.	A side-by-side system exist because captive generators challenge the state(48%) and central (28%) electricity generation. The trend goes towards private (10%) and captive (14%) generation due to greater reliability and lower costs.	Five state-run companies account for half the electricity generation. Independent power producers (IPP) often cooperate with private-arms of the state-owned companies.
Electricity transmission and distribution	Eletrobras allied companies Eletronuclear and Eletronorte produce, transmit and distribute electricity in various provinces.	UES, a state-owned company, controls 96% of transmission and distribution.	Controlled by the State-Electricity-Board (SEB). The 2003 Electricity Act liberalized the monopoly situation by an open access clause for captive producers.	"Heavily state-controlled" (EIA Country Briefing, China) by the State Grid Power Company.

Source: CARMA (2010); Central Electricity Regulatory Commission of India (2009); Goldman Sachs (2007); International Monetary Fund (2010); Kelli (2010); U.S. Energy Information Administration (2010a).

While table 15 distinguished between upstream and downstream phases, table 16 shows differences in regulatory designs to foster electricity generation from renewable sources in general and from hydroelectric systems in particular. Diversity of regulatory designs flourishes among the BRICs in promoting renewables. Support for hydropower, however, seems to be similar in Brazil and India. Both states create incentives by a feed-in-tariff. Furthermore, both legislations favor small-scale projects over large scale ones. While Russia increasingly discovers the potential of its many small rivers, China commits to large-scale projects.

Both findings bring back the discussion on our second hypothesis. It claimed that authoritarian systems can externalize costs which come with the fast and cheap building of stations which are of large scale basically. Democracies need to take further costs into account. This calculation may lead Brazil and India to favor small-scale projects by stimulating small-scale private investment.

Table 16: Regulatory Design

	Brazil	Russia	India	China
Favored policy mechanism	Subsidies and feed-in-tariff (2002 PROFINA), low interest contracts for Eletrobras provided by the Brazil National Development Bank.	Deregulation, completed by 2011, creates 24 bil. US$ in investment, partly from foreign investors such as E.On. Mandatory 4.5% target of RES-E by 2020.	Mandatory quota for distributors to purchase renewable power. Quotas range between 5% and 10%.	Low interest loans provided by the five large state-owned banks, interest subsidies, tax incentives.
Hydropower policy and challenges	Feed-in-tariff promotes small-scale plants, paid by end-user, contract years: 20. Effort is challenged by geographical distance between hydropower generation and consumption. The distance results in high transmission losses.	Approx. 80% of hydropower potential is concentrated in the Far East and Siberia. Investment, however, moves to the European part at a 43.2% to 15.2% ratio. Gazprom-driven efforts to share investment with European companies is not assisted by renewable energy regulation so far.	Feed-in-tariff promotes small-scale (<3MW) hydropower plants. The immense guarantee of 35 contract years shall provide certainty of positive return of investment. Nonetheless, hydropower projects suffer from extremely long environmental approval processes.	The Renewable Law (3rd Pillar) promotes large-scale projects. Investment is provided by the Chinese Government, the World Bank Program CRESP (US$ 87 mil.), and the GEF (US$ 40.22 mil.). Investors increasingly face social and environmental opposition. Furthermore, large-scale projects used to end up far more expensive than expected.

Source: European Bank for Reconstruction and Development (2009); Central Electricity Regulatory Commission of India (2009); Goldman Sachs (2007); International Hydropower Association (2010); International Monetary Fund (2010); Reuters (2009); The World Bank (2010a).

4.1.3 Hydroelectric Large Scale Projects: Brazil vs. China

The concluding subsection compares Brazilian and Chinese project realizations. It is of interest how the respective policymakers respond to political, social, and environmental challenges and costs.

Political costs of building hydroelectric power plants occur if the dammed up river flies through other countries as well. While downstream neighbors were used to an uninterrupted flow beforehand, after a dam is built, they may suffer from low river level, change in river speed and other man made consequences.

As the Bangkok Post reports "China's dams killing Mekong" (Bangkok Post, 2010). Storing up the Mekong River lowers the river level of the upstream neighboring countries. Since Chinese officials refuse to give further information, they act "as a regional bully" (The Economist, 2010a). In turn, officials in Thailand, Laos, Cambodia and Vietnam blame China for its uncooperative behavior.

Brazil takes on a different approach towards its neighbors. In order to avoid a political clash, the Itaipú plant is shared with Paraguay (World Energy Council, 2007). Paraguay also receives electricity from the station. Brazil would not have had to act friendly towards the small neighboring state; the political costs of non-cooperation, however, seemed to be too high.

Social and environmental costs occur because damming up rivers will flood the upstream area. In addition, downstream areas face a drop in the river level and drying valleys. People, villages and entire cities need to be resettled. Such actions can stir emotions and protest because moving homes may not be an easy, cheap and inviting thing to do. The man-made flooding has deep impacts on the biosphere of the riverbanks and the area behind. Animals living in or close-by the water find themselves in a new environment. Both changes can have a devastating impact on biodiversity.

In China, approx. 500,000 people were re-settled during the construction phase of the Xishuangbanna, the Jinghong and the Xiaowan dams. The Three Gorges Damn required the resettlement of 1.3 million people (Reuters, 2009). Of course, the government urges operators to pay compensations and to come up for the re-settlement cost. Protest however, is repressed. "Those who protest are threatened with less compensation, if not jail." (The Economist, 2010a). The 2004 Renewable Law emphasizes the rigor of Chinese government's intervention. According to the third pillar of the "Renewable Law" strengthening especially large-scale projects is a political objective (The World Bank, 2010a).

Brazil nicely illustrates how public opposition to a project can influence policy-making and jurisdiction. The dam conglomerate needed to scale down the Belo Monte station because it faced massive opposition of environmentalists, Indian people, and environmental groups from the U.S. and Europe. At the day of decision "an angry mob" (The Economist, 2010d) was rallying outside the court. As a consequence, plans were changed. "Instead of building a great wall across the Xingu to create a massive reservoir, Belo Monte is designed as a run-of-river dam, a technique that harnesses the natural flow of the river to drive the turbines." (The Economist, 2010d). Obviously, profits from economies of scale effects were exchanged for the non-monetary goods of social peace and acceptance.

Coming back to our second hypothesis, the comparison of the Belo Monte project in Brazil with the Chinese constructions at the Yangtze River contrasted how policy-makers respond to political, social and environmental costs. Generally speaking, Brazil regards these costs as internal to its cost-benefit calculation while in China, some costs seem to have second-order status.[10] This issue has deep impacts on the

[10]For further research on social and environmental costs of China's large-scale hydropower projects

structure of the hydropower projects: While China can exploit the full potential of the economies of scale, Brazil scaled down the Belo Monte project. From a purely qualitative perspective, we consider our second hypothesis to be valid for the two cases. Further generalization is not doable of course.

4.2 National Oil Companies and their Governments

National oil and gas companies are companies whose controlling shareholder is a national government. National oil companies vary in the extent to which political leaders influence corporate decisions, but generally, the purpose of the government controlling an oil and gas company is the perceived importance of using oil and gas resources for issues of national security, economic development, protecting the environment, and often most importantly, securing supply of energy resources. Completely private (i.e. not publicly traded) national oil companies are the largest corporations in the world (Financial The Financial Times, 2006). Typically, these companies are based in developing OPEC countries. By greatest 2009 oil production, the largest of these NOCs are: Saudi Arabian Oil Company, National Iranian Oil Company, Petroleos de Venezuela SA, Petroleos Mexicanos, Abu Dhabi National Oil Company, Iraq National Oil Company, Kuwait Petroleum Corporation, and Nigerian National Petroleum Corporation (Radler and Koottungal, 2009). Further, the national oil companies that are publicly listed are among the largest publicly listed companies in the world.

National oil and gas companies (NOCs) exist in both developed countries (e.g. StatoilHydro in Norway) and developing countries. However, for developing countries, NOCs represent some of the most important tools developing country governments have for gaining international influence and power poorer. In this section, we present a cross-sectional comparative case study of the largest national oil companies in the BRIC countries. In China, two national oil companies dominate domestic oil and gas activity. PetroChina (owned by China National Petroleum Corporation) and Sinopec collectively produce nearly 80% of Chinese oil and nearly all domestic national gas. PetroChina has typically focused on upstream activity while Sinopec has traditionally focused on downstream activities. A third Chinese government controlled oil company, CNOOC plays a smaller role in terms of oil and gas production but dominates Chinese offshore oil and gas activity. In Russia, Gazprom and Rosneft are the large state-controlled oil and gas players. In Brazil, state-controlled Petrobras is the dominant oil and gas producer and in India, the national oil and gas company, ONGC, plays a similarly large role.

Of the 50 largest publicly traded NOCs in the world, 11 are NOCs, 8 of which are in BRIC countries (PFC PFC Energy, 2010). Of the 8 NOCs in BRIC countries,

see Brown and Xu (2010).

PetroChina is the largest oil producer, OAO Gazprom is the largest natural gas producer and PetroChina is the largest company (by market capitalization). Table 17 shows 4 recent statistics for the 7 largest NOCs among the BRIC countries: the share of the NOC owned by the government, the 2009 self-reported production figures for oil and natural gas and their 2009 market capitalization based on the share price of the firm's publicly traded equity on December 31, 2009.

Table 17: Recent Operating Statistics in BRIC Countries

Company	Country	Gov't Ownership Share	Crude Oil Production (mboe)	Natural Gas Production (bcf)	Market Cap. (bil. US$
PetroChina	China	86%	844	2,112	353
Sinopec	China	76%	301	1,687	159
CNOOC	China	64%	186	239	70
OAO Gazprom	Russia	50%	269	16,337	171
Rosneft	Russia	75%	796	448	89
Petrobras	Brazil	56%	771	500	199
ONGC	India	74%	240	969	54

Time: 2009
Source: 8 annual reports.

4.2.1 The Logic of NOCs

Before turning to a comparison of the NOCs in the BRIC countries, we first investigate the logic of why a country may choose to rationally establish an NOC and under what conditions an NOC benefits a country and its people. First, countries that are heavily dependent on oil production may choose to establish an NOC to develop oil and gas resources to maximize social welfare rather than profits. These two goals may come into conflict in this context when it is closer to socially optimal to develop resources over a longer time frame than a profit-maximizing firm would. There is substantial evidence that the reserve to production ratio is higher for NOCs than independent oil companies (IOCs) (Wolf, 2009). This suggests that NOCs produce reserves more slowly, suggesting that NOCs better correct the intergenerational externality of short-term overproduction at the cost of the welfare of future generations.[11] However, this could be a misleading statistic, as NOCs may over-develop resources into reserves for political purposes. Second, in countries that are dependent on either imports or exports of oil and gas as a large fraction of their domestic economy, oil and gas markets may simply be too important to be left to market forces. Through an NOC, governments increase their market share of oil and gas production, and in some cases gain monopoly power. With greater control of supply and prices, NOCs allow welfare to be more closely managed. Third, given

[11] Another explation can be found in 4.2.2.

limited political resources, it may simply be more effective to create a monopolistic NOC because of the natural monopoly characteristics of resource extraction (i.e. geographically concentrated factor inputs, highly specialized and specific knowledge, high infrastructure costs, large economies of scale, etc.). Further, the political costs of establishing new regulatory and enforcing bodies can be avoided by consolidating operators and regulators under the single umbrella of a state-controlled company. Fourth, because NOCs are not bound to the desires of public shareholders, NOCs can enter international markets that are not accessible by IOCs, thus increasing access to energy supply. For example, PetroChina was able to enter into oil production in Sudan while an IOC would have been prevented from doing so (Oil & Gas Financial Journal, 2010). Finally, NOCs afford central governments greater control over an important sector of an economy enabling forms of "resource nationalism." With this perspective, NOCs can be used as political tools to extend the power of the state into both foreign and domestic policy.

4.2.2 How NOCs can be Suboptimal

Depending on the desired outcome, NOCs may be a less desirable structure for large oil and gas companies. First, relative to IOCs, NOCs, may under invest in resource and reserve basin management as the incentives for an NOC may not be aligned with profitability. With a government guarantee and limited competition, executives and non-government shareholders can be isolated from an NOC's suboptimal business practices. Second, NOC activities may be closely tied to the idiosyncrasies of governing regimes. With substantial political realignment, change of political priorities, or some other political shock external to the firm, NOC operating behavior could dramatically shift as a result of forces an IOC would have been immune from. Third, market distortions can be more covertly introduced in resource markets. As these markets are typically international in scope, regional distortions may have undesirable consequences for other regions, particularly resource importing regions. It may be particularly undesirable for energy resource market manipulations to be dependent on political forces intrinsically tied to foreign and domestic affairs.

4.2.3 Data

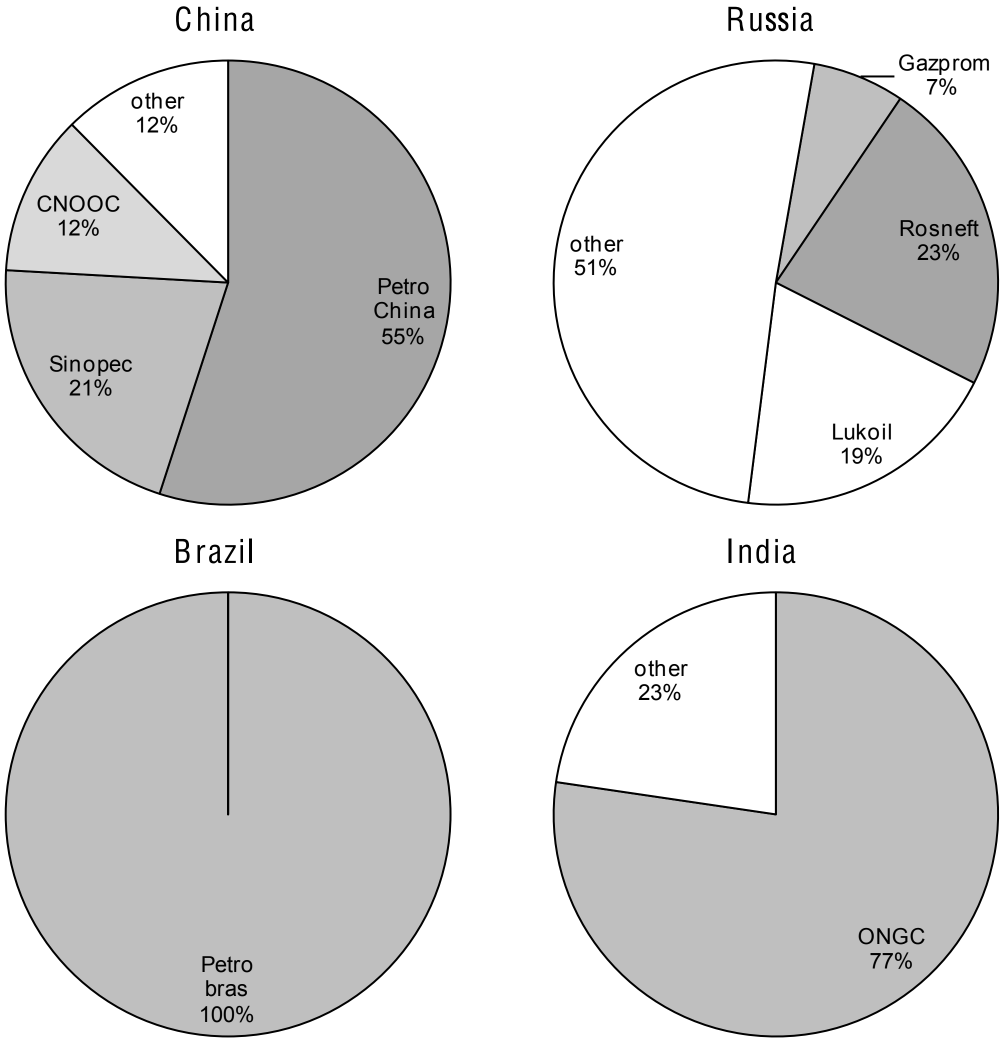
Data on crude oil and natural gas reserves and production for 2009 were collected from the annual reports published by the seven companies in this study. Data from the annual reports were corroborated with data from the Oil and Gas Journal. Reserve and production data were disaggregated into domestic and international (to the firm) activity. For all data except PetroChina's oil and gas production, this data was presented in the annual reports. For PetroChina, the firm's total production data from its annual report was scaled by the ratio of domestic revenue to total revenue. Production and reserve data for the BRIC countries was obtained from the U.S. Energy Information Administration (EIA) for 2009. Since firms reported oil and gas activity in a variety of units, conversion ratios were also obtained from the EIA.

The government's ownership stake in each firm was presented in every annual report. All seven firms have the government as the majority shareholder. The lowest voting equity share of the seven firms is for OAO Gazprom at just over 50% while the highest government voting equity share is for PetroChina at 86.3%.

4.2.4 Government Control of Resources

To measure the degree of control governments exert on energy supply through NOCs, we were interested in measuring the share of domestic oil and gas production and reserves attributable to NOCs. In oil reserves, the two Russian NOCs controlled the smallest share of domestic oil reserves with a combined 46% of Russian oil reserves. However, in magnitude, the oil reserves held by OAO Gazprom and Rosneft were larger than the reserves held by any of the other countries largest NOCs and almost equal in magnitude (>90%) to the oil reserves of China, Brazil and India's NOCs. China's three major NOCs control over 90% of Chinese oil reserves. In oil production, Petrobras is essentially the only producer of oil in Brazil with an estimated 101% market share (the additional percent above 100% is likely due to rounding error). The smallest share of NOC oil production is in Russia where Gazprom and Rosneft together only produced 30% of Russian oil in 2009. Lukoil, a privately-held oil company produced nearly 20% of domestic Russian oil in 2009. Figure 8 shows the share of oil production by NOCs in the BRIC countries.

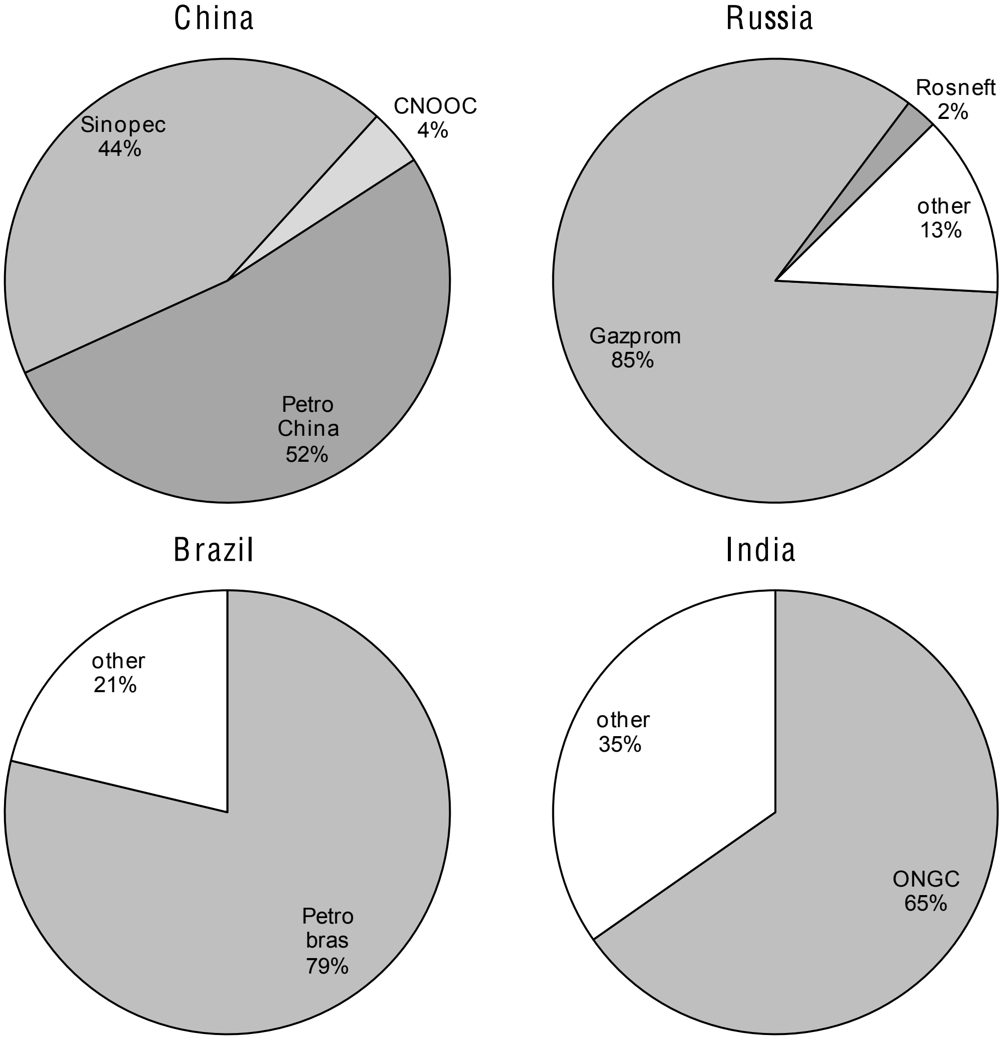
Figure 8: Domestic Crude Oil Production by NOCs in BRIC Countries (2009)



Source: 8 annual reports, U.S. Energy Information Administration.

In natural gas reserves, India's ONGC has the smallest share of domestic gas reserves at 32% of India's total, while Chinese NOCs control the greatest share of domestic Chinese gas reserves at 90%. In magnitude, the natural gas reserves of Russian firms, while only 40% of the Russian total, are more than six times larger than the combined gas reserves of the five other NOCs in BRIC countries. In gas production, there appears to substantial data misreporting among Chinese firms. Combined, PetroChina, Sinopec and CNOOC claim to have produced 25% more natural gas in China in 2009 than the EIA attributes to all of China. Possible explanations for this anomaly are inaccurate country level data reported by the Chinese government, inaccurate data reported by firms in their annual reports, a discrepancy in the definition of natural gas product classes, or an erroneous assumption that domestic gas production is proportional to the share of PetroChina's revenue from domestic sources. ONGC in India has the lowest NOC-controlled share of domestic gas production. Figure 9 shows the share of natural gas production by NOCs in BRIC countries.

Figure 9: Domestic Natural Gas Production by NOCs in BRIC Countries (2009)



Source: 8 annual reports, U.S. Energy Information Administration.

Before proceeding, an important caveat should be acknowledged. As government controlled companies, there are few incentives for NOCs to accurately report reserve data. Politically, under some circumstances, it could be beneficial to signal exaggerated reserve estimates – thereby creating an incentive to develop resource bases into reserves when otherwise doing so would be uneconomical. Further there are definitional reasons for "reserves" that may suggest that reserve estimates have been recorded inconsistently. However, most claims by the firms studied here have been independently audited. Nevertheless, the data extracted from the annual reports of the NOCs should be taken with a grain of salt.

4.2.5 Openness to Foreign Investment and Expansion of International Activity

The share of NOC ownership gives an indication to the extent that domestic oil and gas markets are available to private market actors and foreign investment. Using the metric of share of oil and gas production by NOC firms, Russian oil or Indian natural gas appear to be the largest markets for private and foreign investment. This metric also indicates that Brazilian oil and Chinese natural gas are the markets most closed to private or foreign investment. The openness of energy resource markets could be interpreted as inversely proportional to the resource nationalism governments exert on oil and gas markets. However, governments may also choose to open domestic oil and gas markets to bring in foreign expertise and investment for reasons not directly related to securing energy supply.

Recently, NOCs, particularly from India and China, have expanded their exploration and production activities abroad. With diminishing domestic resources, internal NOC decision makers and their government owners have pushed for increased access to global resource supplies. In the BRIC countries, India's ONGC holds the highest fraction of its reserves internationally. 20% of ONGC's oil reserves and 21% of its natural gas reserves are located outside of India. Not by accident, India also has the smallest oil reserves and second smallest (after Brazil) gas reserves of the BRIC countries. The Russian NOCs remain heavily domestically focused with the largest domestic oil and gas reserves of any BRIC country NOC. Petrobras in Brazil also remains largely inwardly focused, concentrating efforts strongly on commercializing domestically available resources.

International exploration and production is one form of energy supply diversification. This type of diversification helps protect NOC supply from regional disturbances that could affect the availability of supply (e.g. natural disasters, conflict, etc.) as well as from potential price spikes. However, regional diversification incurs additional costs from increased transport distances, the development of region-specific extraction knowledge and technology, and the fostering of political and regulatory relationships and trust in new regions. Further, diversification abroad can induce competition between oil companies attempting to claim production rights over the same resource base.

The relative regional diversification of India's NOC and relative domestic focus of Russia's NOCs provide evidence for the intuitive inverse relationship between domestic resources and international diversification of energy supply. Limited domestic resources relative to demand may drive governments to diversify the resource portfolios of their NOCs internationally. How aggressively NOCs pursue international resource supply (or, for energy exporters, international resource demand) is well predicted by the governance modalities of the NOC's government owner.

4.2.6 Governance and NOC Resource Contracts: India vs. China

China and India, as major energy importers, use their NOCs to aggressively pursue international energy supply. However, the governance styles of the two countries help to explain the differential success rates of Chinese and Indian NOCs in actually attaining contested resource rights. The effect of governance on securing international energy supply through an NOC is well illustrated by events in the past year when Chinese NOCs outbid Indian NOCs for over $12.5 billion in oil and gas contracts. In the past five years, Chinese NOCs have directly bid against Indian NOCs and won contracts in Kazakhstan, Ecuador, Venezuela, Angola, and Uganda (Katakey, 2010). It is also likely that Chinese firms have won even more contracts in competition with Indian firms unobserved because Indian firms did not make an official bid. Chinese NOCs were able to win contracts in competition with Indian NOCs in part because of more readily available financing, favorable exchange rates, and existing foreign currency reserves. However, another important driver in Chinese NOC success in winning international oil and gas contracts has been the Chinese central government's preemptive negotiations to provide financing and aid to countries ahead of the bidding process for their oil and gas resource rights. The ability to provide aid and financing to these countries to implicitly secure resource rights is suspected by many observes to be greatly facilitated by China's more authoritarian government (Bloomberg Business Week, 2005).

In addition to combining the central government's capability to provide aid and financing to other countries with NOC activity, the central government has also used its military to facilitate oil and gas resource rights. In the East China Sea between China and Japan, offshore oil and gas resources lie in ambiguously defined territory. In September 2005, China sent five armed naval vessels near a natural gas field in the East China Sea to intimidate would-be Japanese resource developers (French, 2005). Such drastic measures are representative of the type of decisions that authoritarian governments can make with little domestic check or repercussion.

To secure energy supply, NOCs are used as tools by both democratic and authoritarian governments to expand their sphere of influence. Even though the evidence suggest that privatization of NOCs would lead to more efficient resource extraction (Wolf, 2009), developing country governments are willing to forgo these additional benefits, at least for the time being, to guarantee access to fossil energy resources. While all four BRIC countries use NOCs to guarantee security of supply, the governments of China and Russia, the more authoritarian of the four, also employ other capabilities of their government in conjunction with their NOCs. By integrating NOC activity with other government functions, relative to Brazil and India, China and Russia are more readily able to 1) expand their sphere of influence beyond securing energy resource supply, using NOCs as extensions of the arm of the central government and 2) increase their effectiveness in securing contested energy resources. Further, the governments of China and Russia are willing to use their militaries to support their policy goals in conjunction with their national oil companies, bringing security of energy supply one step closer to the realm of national security.

Coming back to our first hypothesis, the subsections above demonstrate how authoritarian regimes utilize NOCs in order to sustain control over resources and therefore, the capability to control the security of energy supply. Politics enter the sphere of oil and gas supply at various ends, e.g. when international negotiations take place or the military supports security of energy supply. Especially China seems to be far more capable to act rapidly, forcefully and financially potent than Russia and its democratic counterparts.

5 Conclusion

Conventional sources of energy will become more and more scarce as demand for energy resources continues to rise to new levels. While reserves of coal, oil, and gas are geographically diversified, in a globalized world, managing energy resource trade and ensuring access to energy natural resources has become a defining characteristic of security policy. The growth in demand for energy resources is fueled by rapid economic expansion in the developing countries. Brazil, Russia, India, and China, the BRIC countries, are the largest rapidly developing countries: in the past decade nearly one-quarter of global GDP growth occurred in these four countries alone. Yet despite the BRIC countries' collective success in achieving economic growth, their approaches to political governance stand in stark contrast to one another. Russia and China approach governance from an authoritarian history while Brazil and India are established democracies. The past decade's history in the BRIC countries has proved that both authoritarian and democratic governments can achieve economic growth. However, if one of the defining challenges of the coming decades is to secure energy supply, it will become important to ask if both authoritarian and democratic governments will again be able to succeed.

In this paper, we presented the challenge of energy security as defined by two classes of metrics: the availability of fossil energy reserves, and the de-concentration and de-centralization of energy generation. Next, we developed a theoretical framework to situate energy security policy making in the context of governance regimes with alternative political motivations. Finally, we tested the theoretical framework in the context of two comparative case studies one on hydroelectric power and one on national oil companies. By comparing Brazil and India with Russia and China, we were able to control for several of the important similarities that all four BRIC countries share: the relative size of their populations and the size and rate of growth of their economies. This framework allowed us to come closer to isolating the causal effect of governance on energy security policy.

Our pair of comparative case studies in tandem with the quantification of energy security metrics provides evidence for how authoritarian governments shape energy security policy to achieve their objectives. Particularly, the energy security policy established by authoritarian governments are heavily influenced by their objective to seek control and power. We find that in states with authoritarian governance, power production is more concentrated than in democratic countries, facilitating control over the supply of energy services. Second, we find that states with democratic governance better internalize the social and environmental costs of developing energy generation units. Finally, we find that how authoritarian governments utilize their national oil companies reflect both their ability to exert their power through multiple channels and their desire to control and directly benefit from natural resources.

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