Examination of energy sector:
The implications and effects of financing for innovations, corporate governance for company value, and resource abundance and corruption for investment attractiveness

A thesis submitted
for the degree of
Doctor in Philosophy
in the subject of
Economics

by
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October 2012

Abstract

In this dissertation, the examination of energy sector development is presented. The purpose is to understand and highlight the importance of financing access for innovation activities, along with the business transparency necessary for firm value and the impact of corruption on capital investments in energy companies.

Globally, long-term energy confidence is dependent on energy security and supply. Based on our empirical estimations, we expect there to be an increasing need for understanding financing innovations in the European energy industry. We expect more support for corporate governance integrity within Russia, as Russia is the main energy supplier for the European energy sector. It is expected that corruption will be a dominant issue for countries that are rich in natural resources.

The main empirical findings and concluding comments are as follows:

- The EU energy sector requires substantial financial support for promoting innovations, especially among 'younger' energy companies and those in the newest EU countries.
- We expect to see increased discussion and long-term development of corporate governance integrity (transparency and disclosure, in particular) among Russian energy firms based on the long-term investment attractiveness of sustained energy production and supplies to countries that are energy dependent.
- We conclude that investment activities in natural resource exploitation are directly linked with the presence of corruption, and that tightening up on corruption should facilitate FDI (foreign direct investment) in the primary industry and enable the effective use of received natural resource gains.

To summarise, in this assessment, we empirically studied the EU, Russian and global energy industries, focusing on the issue of the development of energy within three key areas: the examination of financing for innovation, corporate governance integrity and corruption within primary FDI inflows.

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Acknowledgments

I would like to thank my supervisors Doctor Sarmistha Pal, Doctor Matthew Rablen and Doctor Charles Grant for their invaluable ideas and comments on the many drafts of each chapter. They performed their supervisory duties in a friendly, timely and efficient manner.

I am grateful to the participants of the various workshops and events organised by the Department of Economics, and especially comments on the earlier draft of Chapter 4. They helped me to clarify and improve my research. I also acknowledge the comments of S&P's (Standard and Poor) governance team and their willingness to share their data with me, as used in Chapter 4.

The two years of funding provided by Renewable Energy Systems Ltd. to undertake my research studies is gratefully acknowledged.

Declaration

I hereby declare that I have not used before or published any material contained in this thesis. A version of Chapter 4 has been submitted to the Journal of the Economics of Transition and has been later re-submitted to the Journal of Banking and Finance. If eventually accepted for publication, this will not be until after the viva voce examination.

I declare that this thesis is my own work. A version of Chapter 4 has been submitted for publication jointly with my supervisor, Doctor Sarmistha Pal, reflecting her input during her supervisory role.

I declare that this thesis has not been submitted for a degree at another university.

CHAPTER 1

1. Background

In this dissertation, the examination of energy sector development is presented with the aim of understanding the importance of efficient, long-term industry sustainability. The empirical analysis is built on the concept that the energy industry is at the core of economic development and societal wealth. That is, the energy industry is a fundamental block of an activity within a country where a reliable sector provides long-term guarantees of energy supplies.

Virtually every activity is dependent on energy supply, from households to the public sector, and from manufacturing enterprises to transportation activities. As such, all economic and social activities require confidence in a stable energy industry. The benefits of an efficient energy sector are the creation of employment, earnings and taxation, the outputs of exploration and production companies, and distribution and supply of the energy sources to those who require them. Thus, the constant development of the energy sector, the transparency of the sector and the security of the resource supplies are all critical factors in a stable and long-term supply. As such, these three areas form the examination of the energy industry:

- First, the development of the energy sector is dependent on research and development activities, which are known to be capital intensive. These innovation activities, in turn, require substantial financial support. Thus, in the first empirical study, we examine financing for innovations within energy companies.
- Second, the development of the energy sector is dependent on investor confidence, and transparency of such a complicated business is a vital factor. Following that, we examine the effects of corporate governance (CG) integrity within energy companies, which should stimulate firm value and, therefore, should attract investors.
- Third, securing energy supplies leads to investment in resource-abundant countries, providing not only secure energy supplies, but also substantial resource exploitation gains for the host countries. We therefore examine the impact of natural resource activity and the existence of corruption on

primary foreign direct investment (FDI) inflow attractiveness in the host countries.

Despite the increasing research in the given areas of the energy industry, these issues remain unexplored. We hope the examination we pursued and the empirical results we obtained will provide additional understanding of these issues, and encourage further discussion among policy-makers and company management in order to foster a better understanding of the long-term needs and development of the energy industry.

First area of study: Financing for innovations

In the first empirical analysis, in Chapter 3, the financing of research and development (R&D) is examined. R&D is considered to be of paramount importance for an economy, as technological innovation is a key driver of economic growth (Solow, 1957; Myers, 1977; Rajan and Zingales, 1995). Indeed, Balakrishnan and Fox (1993) and Mulder (2008) argued that investment in energy does not pay off in innovation activities, and it requires substantial levels of subsidies, which lead to investor uncertainty in R&D decision-making scenarios. In addition, the knowledge gained regarding new goods and services cannot be kept secret and therefore cannot be enjoyed solely by the investing firm, but also by other companies operating in the industry. Hence, the latter may act as an impediment to the financing of research and innovation.

In this analysis, the particular focus is on the European energy sector. The need for R&D activities has been increasingly highlighted by the EU commitment announced in March 2000 in Lisbon. The EU Heads of State and governments set the target of becoming the most competitive and dynamic knowledge-based economy. However, more importantly, innovation in energy technology is becoming increasingly important in terms of meeting the growing demand for energy amidst concerns about the security of energy supplies and calls for greater environmental protection.

At the same time, the present knowledge about financing innovation in the energy industry remains rather limited. Much of the existing literature consists of country level empirical studies (Bhagat and Welch, 1995; Rajan and Zingales, 1995) and only some firm-level studies relate to the energy industry (see Balakrishnan and Fox, 1993 on the mining sector and Mulder, 2008 on the wind energy sector).

Thus, the analysis contributes to the limited literature on the firm-level financing of innovation in the energy industry. Furthermore, the differences between the two major European energy sectors – utilities and oil and gas producers – are highlighted. To the best of the author’s knowledge, this has not been tackled in the existing studies.

Second area of study: Corporate governance (CG) integrity for firm value

The second empirical study, in Chapter 4, is motivated by the significant importance of Russian energy companies providing energy supplies to the European region. In general, existing research highlighted that financial markets attract higher prices and provide investment incentives when CG laws protect investors against expropriation by controlling owners. In limiting expropriation by the controlling owners, CG laws encourage external financing of corporate investment and, thus, value and growth.

The analysis is focused on Russia, which is a special case in point. Until 2002, Russia had no recognised accounting standards or other official CG mechanism capable of ensuring the type of corporate integrity within companies to stimulate investment incentives and financial markets. The introduction of CG codes in 2002 marked a significant development in Russia's corporate history. Although Russia quickly caught up with the West in adjusting its company and bankruptcy laws to Western standards, low protection levels for property rights remain a preferred policy of the rich in a country plagued with a very high degree of income inequality due to widespread corruption in the courts, regulatory bodies and law enforcement agencies (Pistor et al., 2000). In this respect, Russian firms are greatly undervalued and, therefore, need to adhere to higher CG standards to induce external investment.

The question raised by the research is whether the introduction of transparency and disclosure (T&D) in this type of investment climate can boost firm value. While the introduction of T&D rules (and overall CG codes) can resolve the conflict of interest between the controlling and minority owners, it may worsen the conflict between the state and the controlling owners: increasing the transparency of businesses may make them easy targets for aggressive tax-enforcement policies.

In the absence of any prior evidence in this regard, this chapter empirically explores the net effects of the introduction of CG codes in Russia, with special reference to T&D rules.

Third area of study: Natural resource abundance and corruption in relation to FDI

The final empirical analysis, undertaken in Chapter 5, was facilitated by the existing research, which suggests that FDI is regarded as a good instrument for economic policies, providing the potential for economic growth. Nevertheless, the studies highlighted the issue of attracting investments to those industries with greater economic returns, in particular, for natural resource-rich countries, where those natural resources provide higher economic rents compared to other industries (Dunning, 1974 and 1980; World Bank, 2006;

Bhattacharyya and Hodler, 2009; Poelhekke and van der Ploeg, 2010). More importantly, it is emphasised that corruption exists at every stage of natural resource activity, from pre-exploration activities and licensing agencies, to complex financial arrangements, because corruption allows investors to protect their returns and governments to stay in power (Bloningen, 2005).

In this regard, the analysis contributes to a growing literature on natural resource abundance and corruption for primary FDI investments. While earlier literature tended to focus on aggregated FDI (Smarzynska and Wei, 2000; Bloningen, 2005), the focus in more recent literature has shifted to natural resource foreign capital investments (Asiedu and Lien, 2011; Poelhekke and van der Ploeg, 2010). For instance, Kronenberg (2004) explored the effects of natural resource intensity on economic development, but not on FDI. In a more recent paper, Bhattacharyya and Hodler (2009) focused on the relations between natural resources and corruption. In another study, Asiedu (2002) and, later, Asiedu and Lien (2011) linked resource activity with the effects of democracy. Poelhekke and van der Ploeg (2010) and van der Ploeg (2011) explored the effects of natural resources on FDI through institutional quality, but the authors considered aggregated FDI, not primary FDI. The general agreement is that resource abundance and the resulting potential economic benefits both influence and are influenced by the institutional environment.

The analysis goes beyond the above-mentioned literature in that, in the absence of prior evidence, the research has allowed for the identification of the possible means through which the introduction of access to natural resources can influence FDI inflows in the primary sector. In doing so, the analysis highlights that corruption, as a proxy of the institutional environment, is especially prone to primary FDI decision-making, after controlling for other factors. We are not aware of any existing study that considers the effects of natural resources and corruption on primary FDI inflows.

1.1. Aims and objectives

The aims and objectives of the dissertation are as follows:

- The aim of the second chapter is to provide theoretical background knowledge. This chapter is intended to explore the panel data-estimation models that we consistently refer to throughout the empirical chapters.
- The aim of the third chapter is to examine the role of financing access to R&D activities. The particular focus is on European energy firms’ access to finance

and examination of the leverage effect on R&D (lower leverage facilitates higher R&D, while higher leverage adversely affects R&D). The study is conducted in the light of the growing demand for energy alongside concerns about security and stability, as well as the rising demand for new technologies for the more efficient use of energy. Further, the effects of operating income availability as an internal financing boost for R&D activity is studied in periods when it is difficult to obtain external borrowing. The analysis is based on more than 250 companies located within 24 old and new European member countries, between 1995 and 2007. The data for the analysis was primarily obtained from the Bureau van Dijke Electronic Publishing (BvDEP) OSIRIS database.

- In the fourth chapter, the role of CG mechanisms is explored, especially regarding whether T&D rules can boost firm value. The research focused on Russian companies, which cumulatively covered 80% of the Russian Stock Market capitalisation in 2007. In particular, we concentrated on energy sector firms. Focusing on Russia until 2002 was of special interest, as this country had no recognised accounting standards or a CG mechanism to ensure integrity within companies that could stimulate investment incentives and financial markets. The study is based on T&D indexes obtained from Standard and Poor's (S&P's) data for 2003–2007, while the overall CG examination extended the analysis for the years 2000–2008, where the most firm-level observations are available. Firm-level data was obtained from the OSIRIS database.
- The fifth chapter examines the roles of natural resources and corruption in attracting FDI inflows in the primary sector. This is based on the notion that, generally, FDI has been recognised as a good instrument for economic policy. However, the decisions in allocating FDI are made by considering the expected profitability of the investments – in particular, for countries that are rich in natural resources, where the natural resource gains are greater when compared to other industries. Further, it is emphasised that corruption exists at every stage of natural resource activity, from pre-exploration of the resource to financing arrangements and the share of economic gains, allowing investors to receive their returns and governments to stay in power. The analysis is based on a panel of more than one hundred countries that have an abundance of natural resources, covering the period from 1992 to 2001, with a primary focus on

inward FDI data availability from the United Nations Conference on Trade and Development (UNCTAD) database.

- The final, sixth chapter provides the main findings and concluding comments, and derives implications for energy sector companies and governments, where possible. The limitations of the study and scope for further research are considered and explained.

1.2. Significance of the dissertation

This research integrated the literature on energy sector development: the financing for R&D activities in European energy companies; the impact of CG (T&D, in particular) on the value of Russian energy companies in attracting investment; and the relationship between natural resource abundance and the presence of corruption, as it affects primary FDI inflow attractiveness at a country level. In doing so, the issue has been considered from the point of view of energy firms and two major subsectors (utilities and oil and gas), from non-energy sectors and in terms of the overall effect for all companies. The questions raised and the hypotheses introduced are mostly unexplored in the existing literature. Therefore, the implemented empirical analyses add value in terms of providing a better understanding of the energy sector.

In essence, the research aimed to examine three emerging questions regarding the development of the energy sector:

- What is the relationship between general corporate leverage and innovation activities (R&D) in the European energy sector?

  This was of interest because innovation in energy technologies is becoming increasingly important for securing the growing demand for energy, but the knowledge regarding financing innovations is rather limited. The empirical results showed that companies that are less financially overburdened experience advantages with higher R&D levels, which have been influenced by other control factors, such as tax shields, firm maturity, EU integration and the ownership status of the companies.
- How do Russian energy firms introduce CG?

  This was important to explore because the CG mechanism is a significant element that affects how attractive a firm appears to be in the eyes of potential investors. This is especially important for Russian energy companies, which are the main suppliers for the European energy sector, yet until 2002, there was no common corporate integrity mechanism to otherwise induce investment incentives in Russian energy companies from outside investors.

The empirical results showed that the introduction of CG codes, information transparency and disclosure in particular, have boosted firm value in both energy and non-energy sector firms. However, the limited effect of information disclosure for oil and gas companies might have contributed to fears that too much transparency might open firms to attacks from the state and from competitors.

- What is the effect of natural resource abundance, corruption and their interaction on primary FDI inflows worldwide?

  We followed the complex relationship between natural resource activities, which provide higher economic gains compared to other industries, and the existence of corruption at every stage, from resource findings to financial arrangements, and the interaction with FDI, as FDI has been regarded as a good instrument for economic development. In the absence of prior empirical evidence, in this study we argue that corruption significantly undermined primary capital investments in natural resource activities.

We hope that our findings in answering these three questions will stimulate interest through a better understanding of financing R&D, CG and corruption toward capital investment activities in the energy sector for the countries studied. First, financing for R&D should be controlled, so as not to overburden companies' liabilities, and other incentives are able to stimulate innovation activities. Second, the introduction of CG mechanisms has been successful in providing a better investment climate for energy companies. However, such mechanisms should be introduced carefully; otherwise, too much or too rapid a corporate information disclosure may lead to fear on the part of the owners and may curtail corporate effectiveness. Third, the focus on corruption, natural resource gains and the effect of these two factors on primary FDI inflows suggest that better corruption control should be in place to encourage capital inflows in the energy sector.

1.3. An overview of the empirical chapters

The present study consists of three main empirical chapters. First, Chapter 3 examines the importance of financing for innovations in the European area, as R&D is becoming increasingly important in terms of meeting the growing demand for energy amidst concerns of supply security in the common European territory. Second, Chapter 4 advances to the Russian energy companies, which are the main energy suppliers to European countries. In doing so, the control for the effect of CG integration is implemented, which may allow for greater company value and, therefore, higher levels of credibility from investors. Third, Chapter 5, through non-European and non-Russian companies, examines the global importance of the abundance of natural resources and the impact of corruption on attracting primary FDI inflows. This was of interest because the interrelated effect of these two factors in attracting FDI is unclear: natural resources attract FDI because of high economic gains; however, corruption exists at every stage of natural resource wealth.

Chapter 3: Financing innovations: Implications for European energy sector firms

We examined the role of financing for R&D activity (using leverage as the ratio of debt to total assets, and R&D as the ratio of R&D expenditure to total assets) and operating income availability for energy companies in the European countries. We were able to control for the energy sector in general and were also able to distinguish between two major sectors: utilities and oil and gas producers. We found empirical support for our two hypotheses that a lower leverage level and availability of operating income enable the promotion of investments in R&D in energy companies, even after controlling for other factors.

We found that a moderate financing level allowed companies to attract investments, resulting in the financial support for innovation. Regarding the control in terms of leverage, lower debt levels stimulated innovation in the energy companies, whereas over-financing adversely affected R&D activities, irrespective of sector choice. Estimates of operating income demonstrated that financing in 'younger' companies was enhanced by operating income availability. Control for additional factors showed that privately owned companies (owned by other companies) were more likely to attract financing compared to state-owned firms. Further, we found that companies in the established EU countries were in a better position to receive financing sources compared to energy firms from new EU member countries (those who have joined since 2004). Overall, the findings supported those of Balakrishnan and Fox (1993), Bhagat and Welch (1995), Rajan and Zingales (1995) and Booth et al. (2001). The findings on control measures are in line with Audtretsch (1991), Shleifer (1998), Brown and Medoff (2003), Gros and Mortensen (2004) and Ayygari et al. (2007).

The empirical results are explained in a number of ways:

- First, a lower leverage level stimulates activities in R&D because controlled financing allows for financial liabilities not to be overburdened, which are associated with greater uncertainty of future returns from investing in innovations.
- Second, ‘younger’ companies (different age group periods are introduced) are less credible in the eyes of lending institutions. That is, more mature companies tend to have easier access to financing because lending institutions use firm age as a proxy for economic sustainability and greater market experience. This is why the estimates for operating income availability are significant for ‘younger’ energy companies, as it is used as a financing boost towards innovation activities.
- Third, estimates show that privately owned energy companies are better at attracting financing for R&D because private companies are stimulated by competition incentives with other companies. This is in opposition to state-owned companies, which are often characterised as being monopolistic giants lacking development in the absence of a competitive environment.
- Finally, the results on EU integration demonstrate that companies in old EU countries have an advantage in securing financing for innovation versus those companies in new EU countries. This is, perhaps, because there are not enough financing incentives in place (or they may not be readily available) within new EU member states. For instance, the estimates show that tax incentives are significant among companies located in established EU countries, but are not significant for those firms in new EU countries.

The importance of the study is that it has focused on the European energy sector, distinguishing between two major subsectors, which, to our knowledge, have not been examined in the firm-level literature on financing and innovations.

In future research, the aim is to examine the differences in the factors for R&D between two major energy sectors: utilities and oil and gas. That is, we can contribute to knowledge on the sustained improvement in innovation for R&D in the energy industry, especially concerning energy companies in new EU member countries.

Chapter 4: Does corporate governance reform necessarily boost firm value? Recent evidence from Russia

While the effect of financing on R&D in the energy sector has been pronounced, there is a great deal of variety in the CG mechanisms in place across the main energy supplier for the European region – Russia – which remains rather underexplored. This is partly because CG has been in place only since 2002, which means that only relatively recently have international investors acquired opportunities to assess commonly used international management standards and accounting principles in relation to such an important energy industry. Therefore, the role of the effects of CG mechanisms on firms' value (measured through Tobin's Q) is examined for the Russian energy companies, with an extension into the two major sectors, utilities and oil and gas, as well as non-energy industries. We considered not only the role of CG, but also T&D rules. The analysis focused on the largest listed companies in the Russian energy sector, including such energy giants as Gazprom, Lukoil, Rosneft and the TNK-BP (British Petroleum) Holding. The S&P's T&D indexes were used for the proxy of CG, where firm-level data was obtained from the OSIRIS database. There are three sets of estimates for examining the significance of CG implementation and T&D evolvement and, as such, which contribute to the growing literature on Russian CG practice:

- First, T&D, and especially financial and operational sub-measures, was found to be important for a company's value in the energy sector, which is the driving force for all industries pooled together.
- Next, the overall introduction of CG is considered (as a binary indicator) with demonstrated support for the importance of T&D control within firms, especially for those listed on international stock markets, as it allows a company to gain greater investor credibility. It became apparent that CG enforcement was weaker when it related to T&D factors, perhaps highlighting the conflict of interest between the state and the controlling owners, especially in the oil and gas subsector. That is, too much transparency may weaken companies in such a competitive environment.

Taken together, while the introduction of CG reform has been successful in resolving the conflict of interest between minority and controlling owners, it has generated a conflict of interest between the state and the controlling owner, which to some extent contradicts with the purpose of introducing CG reform in the first place. The latter has gradually paved the way for foreign investment in Russia, which has been highlighted by the BP investment in the oil and gas sector of the country.

It would be interesting to see whether and how foreign multinational investments can resolve the conflict of interest between the state and the controlling owner, thus contributing to the sustained improvement in firm values in Russia. We aim to examine this in further research.

Chapter 5: Resource abundance, resource rents, corruption and FDI: A panel-country analysis

In the final chapter, the roles of natural resource abundance and the existence of corruption in terms of FDI inflows in the primary sector have been examined. The results also compared estimations of the overall FDI inflows in the countries under observation.

Existing studies have shown that the extent of institutional mechanisms may or may not lead to decreasing or increasing primary FDI inflows; that is, the impact of resource activity and corruption on FDI is unclear. While much of the natural-abundance resource literature has focused on aggregated FDI, a limited number of studies pertained to primary FDI, and even fewer explored the effects of natural resource-richness on resource investments. We examined the complex relationship between natural resource activities, corruption and FDI inflows in the primary industry. Our main FDI source was the UNCTAD dataset, where natural resource rents are from the World Bank, and corruption was measured using the International Country Risk Guide's (ICRG) proxy.

In the context of the natural resource levels and corruption, this analysis contributes to a growing body of literature on primary FDI investments through the examination of three hypotheses:

- Whether greater access to natural resources promotes primary FDI.
- Whether greater corruption increases or decreases inward FDI in primary FDI.
- Whether the effect of natural resource activity on primary FDI depends on the extent of corruption.

The analysis focused on a panel of 133 natural resource-rich countries for the 1992–2001 period, when most primary FDI observations were available from the UNCTAD database. We found evidence that the presence of corruption significantly reduced the attraction of natural resource activities and, therefore, significantly impacted FDI investments in the primary industry. However, the effects of income from natural rents and corruption remained insignificant for total country level FDI, even after controlling for other measures (trade openness, GDP per capita, credit provided by the banking sector, the military being involved in politics and infrastructure [established through the number of telephone lines]).

We explain our findings in that natural resource-rich countries are not only attracted by resource exploitation possibilities and the potential of receiving high economic gains from the investments, but also that corruption becomes a factor, which is proxied for in terms of the institutional quality.

In other words, corruption, on the one hand, eases access to natural resources and allows for profits to stay with investors, but on the other hand, the presence of corruption weakens FDI, as investors are likely to be asked for bribes and are required to bear extra contractual risks. Nevertheless, the natural resource remains highly economically attractive. This is why, despite the presence of corruption, primary industries still attract investor attention around the globe. This also, perhaps, explains the weak exposure of natural resource gains to other economic sectors: investors may prefer greater returns in the corrupted environment compared to lower returns in the more stable industries. These investment priorities are highlighted in a number of existing studies (e.g. Hausman and Rigobon, 2002; Kinoshita and Campos, 2010; Poelhekke and van der Ploeg, 2010).

Overall, this study revealed that corruption is especially prone to primary FDI decision-making events after controlling for other factors. We are not aware of any existing study pertaining to the effect of the relationship between natural resources and corruption on primary FDI inflows.

CHAPTER 2

2. Theoretical methodology for the empirical estimations

This chapter explains the theoretical background that we consistently rely on during the empirical assessment. The theoretical background mechanics are well documented in corresponding studies (e.g. Arellano and Bond, 1991; Baltagi and Wu, 1999; Greene, 2002; Woldridge, 2002, Baum et. al., 2009; among others); hence, the purpose of this chapter is to demonstrate that we are aware of the issues and the related analysis specifications which we have to consider.

The examination of the energy sector highlights the need for appropriate theoretical modelling to be able to study multiple observations on the same economic units over a given time period (firms or countries and years, in our case). For this reason, panel data analysis has been applied, specifically with a large number of observations and a smaller number of time periods. Furthermore, we deal both with balanced and unbalanced panel data. Following Greene (2002), there is no clear advantage from the econometric perspective in operating with data having all the cross-sectional units captured within each time period (balanced panel) or if the panel has some missing observations (unbalanced panel).

Below, we discuss the most common types of panel data analytical estimations such as the pooled ordinary least squares model (pooled-OLS), random effects (OLS-RE), fixed effects (OLS-FE) and first differencing (FD). We also cover a dynamic type of panel data with the application of a GMM estimator. Along with the panel data description, we summarise the common issue of heterogeneity, heteroscedasticity, the inclusion of time effects, the joint test for the significance of the explanatory variables, weak instrument identification and a test for over-identifying restrictions.

We start with the simplest type model, the pooled-OLS model, which has a constant coefficient in both the intercept and the slopes. In this model, each observed element will have two subscripts: the company (or country) identifier ‘i’ and a within-group timing index ‘t.’ This form of the model clarifies that there is no significant effect that has occurred within the company (or country) and across the time period observed. Although this assumption may exist, most of the time, there will be either a specific observation or time-based effect, and hence, we have to consider employing other specifications. That is, we start with the pooled-OLS equation:

$Y_{it} = \beta X_{it} + \alpha_i + u_{it}$ (Eq. 2.1)

where

Y_{it} = an independent variable,

β = is the coefficient of X,

X_{it} = is a matrix of variables (or regressors) that vary over individual units (firms, companies) and time,

i = 1,…,N is the number of individual units,

t = 1,…,T is a number of periods as years,

α_i = the unobserved time-invariant unit-specific effect,

u_{it} = is a unique time-varied observation-specific error term.

The given equation should meet two assumptions. That is, the unobserved time invariant 'α_i' should not correlate with 'X_{it}' variables and there should not be a correlation between the observation-specific error term 'u_{it}' and the 'X_{it}' regressors:

$E(\alpha_i | X_{it}) = 0$, an assumption of mean independence,

$E(e_{it} | X_{it}) = 0$, an assumption of exogeneity.

In this instance, if the unobserved variables included in the model are believed to be random and uncorrelated with the independent variables satisfying the assumption of mean independence: $E(\alpha_i | X_{it}) = 0$, the random effect (OLS-RE) model may be implemented. However, if there is a correlation between the individual and/or time effects and the independent variables imposed: $E(\alpha_i | X_{it}) \neq 0$, the OLS-FE specification may be applied in order to mitigate the endogeneity issue.

The general way to justify the selection between the two is through the use of Hausman test. The Hausman test examines the difference between the two estimated covariance-matrixes towards weighting the difference between the 'RE' and 'FE' vectors of the slope coefficients. The hypothesis rejection, in which there is a correlation with an insignificant p-value and 'Prob>Chi2' greater than 0.05, suggests the application of the OLS-FE model. That is, the 'FE' specification accounts for 'α_i' to be a group-specific constant term in the regression model.

The alternative to OLS-FE, which removes the control for the heterogeneity, can be exercised through the FD of the original pooled-OLS model removing the constant term (Wooldridge, 2002). Through the differencing, the first time period for each cross section will be lost; that is, there will be '$T-1$' periods for each observed 'i' rather than 'T.' That is, in recalling Eq. (2.1), the first differencing form of the regression using two periods will become:

$\Delta Y_{it} = \beta \Delta X_{it} + \Delta u_{it},$ (Eq. 2.2)

where

Δ is the change from e.g. the time period t=0 to t=1:

$\Delta Y_{it} = Y_{it} - Y_{it-1}$,

$\Delta X_{it} = X_{it} - X_{it-1}$,

$\Delta u_{it} = u_{it} - u_{it-1}$.

The advantage of the first differencing is that the fixed effects 'α_i' have been removed, relaxing the assumption that 'u_{it}' is uncorrelated with regressors '$X_{it.}$' The general intuition of first-difference estimation is that it implies the within-unit changes, but not the between-unit changes.

Dynamic panel data (GMM estimator)

However, the inclusion of a lagged dependent variable 'Y_{it-1}' on the right-hand side of the regression may make the OLS-FE model yield biased estimates. The presence of the lagged dependent variable creates dynamic panel bias, causing the correlation between the explanatory and error term 'e_{it-1}', which is a function of the time-invariant, country specific fixed effects 'α_i' ($e_{it} = \alpha_i + u_{it}$).

The appropriate and preferred estimator for the dynamic model is the GMM estimator proposed by Arellano and Bond (1991). This estimator removes the country fixed effects through the differencing, and any endogeneity that might arise due to a correlation between country FE and explanatory variables will be removed. That is, first, the fixed effects need to be removed from Eq. (2.1) through the first differences, as per Eq. (2.1): $\Delta Y_{it} = \beta \Delta X_{it} + \Delta u_{it}$.

Yet, when the fixed effects are removed, the lagged dependent 'Y_{it-1}' variable is still potentially endogenous: 'Y_{it-1}' in $\Delta Y_{it-1} = Y_{it-1} - Y_{it-2}$ and is correlated with $\Delta u_{it} = \Delta u_{it} - \Delta u_{it-1}$. Similarly, any other regressors 'X_{it}' that are not strictly exogenous become potentially endogenous as these may also relate to u_{it-1}. In order to obtain consistent estimates, the lags for the endogenous instruments are required: consequently, this will not relate to $\Delta u_{it,}$ and will also allow for a large enough sample estimation. The second lag is often introduced because it does not correlate with the error term, while the first lag does.

Potentially, the higher number of lags may result in a better instrument, but this would reduce the size of the observations:

Y_{it-2} is mathematically related to $\Delta Y_{it-1} = Y_{it-1} - Y_{it-2}$
but not to the unique error term $\Delta u_{it} = u_{it} - u_{it-1.}$

Following Arellano and Bond's GMM estimator, the lagged dependent variables treated as endogenous, and the independent variables are treated strictly exogenous. GMM estimator used the second lag of endogenous variable.

Introduction of the dynamic panel data models requires testing for the weak instruments and the test for the overidentifying restrictions. The 'weak instruments' issue refers to the level of potential correlation (nonzero but small) between the endogenous regressors and the excluded instruments. In other words, there is a potential of selecting the "weak" instruments that are poor predictors of the endogenous predictor in the first-stage equation. The F-statistics is often used as a test for weak-instruments (Baum et. al., 2007).

When the additional external instruments are introduced, the validity of the moment conditions under the dynamic panel is commonly tested for the overidentifying restrictions. The two similar tests associated with the overidentification are the Sargan test (Sargan, 1958) and Hansen test (Hansen, 1982). Both tests are based on the notion that the residuals should be uncorrelated with the set of exogenous variables if the instruments are truly exogenous.

Heteroscedasticity, joint testing, time effects and elasticity

With regard to panel data estimation techniques, we are also aware of related issues such as heteroscedasticity, a test for the joint significance of the explanatory variables included and a time effects test to determine whether a control for specific unobserved effects is required.

At first, a heteroscedasticity test detects violation of the panel assumption that the conditional variance is not dependent on the 'X_{it}', and that the unconditional variance is the same for each of the periods. In other words, heteroscedasticity is expected to be found in the disturbance term when dealing with companies or countries that vary in size. As noted by Wooldridge (2002) the presence of heteroscedasticity on its own does not affect the consistency of the estimators. Heteroscedasticity due to group-wise differences can be mitigated by considering the group means. Heteroscedasticity can commonly be assessed with the White, Breusch-Pagan or Wald tests for group-wise heteroscedasticity. The null hypothesis tested is the presence of homoscedasticity (or constant variance), while rejection of the null will indicate the existence of heteroscedasticity.

As noted above, the presence of heteroscedasticity causes the standard errors to be biased compared to the OLS assumption that the errors are independent and identically distributed. Throughout the empirical analysis, we apply White’s standard errors to account for heteroscedasticity. This application of robust standard errors will relax the assumption that the errors are identically distributed.

Second, we consider the joint test hypothesis that allows testing whether selected explanatory variables have an effect on the dependent variable selected. For instance, in the first empirical chapter (Chapter 3), we were interested to know how the debt and operating income variables affected R&D. To this end, we included explanatory variables such as liquidity and tax proxy and tested whether these were jointly significant. The null hypothesis is that none of the selected right-hand-side variables explain the dependent variable. The alternative test is that at least one of the selected variables explains the dependent variable. Rejection of the null hypothesis would mean that the variables examined are jointly significant and need to be included.

Third, we include a timing effect control. Time effects can account for unexpected variation (events) that may affect the dependent variable. These events may include inflation rates, GDP data, accountancy rules and institutional regimes, etc. A proxy to deal with such factors is to control for time effects (time dummies) within panel data models to solve for the potential endogeneity issue. To establish if the time effects are required, we refer to a joint test to see if the coefficient dummies for the time period examined are equal to zero. Failure to reject the null hypothesis that the year coefficients are equal to zero will mean that no time effect control is required.

In addition to panel data techniques and post-estimation tests, we discuss estimation results in terms of elasticity. Elasticity is a tool that is applied to measure the sensitivity or responsiveness of the dependent variables to a change in the explanatory measure (e.g., Bagad, 2008). The advantage of elasticity over the estimated coefficients is that it avoids the likely issue of unit sizes. Responsiveness is measured in proportionate (percentage) terms (Wang and Jain, 2003). The mathematical expression is:

$$E = (\Delta Y/ \bar{Y}) /(\Delta X/ \bar{X}) * 100$$

where

E = elasticity, and $\bar{Y}$ and $\bar{X}$ denote the average values of the measures.

Estimated coefficients would essentially produce the elasticity of dependent ‘Y’ to explanatory variables denoted as ‘X’. In other words, the elasticity measure is defined as the percentage change in ‘Y’ for a 1% change in ‘X’.

At first, the degree to which the dependent variable reacts to a change in the explanatory variable can be perfectly inelastic (E = 0), inelastic ($|E| < 1$), elastic ($|E| > 1$) and unit elastic ($|E| = 1$). Second, the sign of the elasticity indicates the direction of change; for instance, a negative sign would mean a negative proportionate effect between ‘Y’ and ‘X’. A perfectly inelastic relationship would imply that a change in the explanatory variable ‘X’ creates no change at all in the ‘Y’ dependent variable, i.e. the change in ‘X’ is irrelevant to ‘Y’. An inelastic relationship implies that the dependent variable is relatively insensitive to the explanatory variable. For instance, $|E| = 0.5$ means that a 1% change in the ‘X’ explanatory variable will lead to 0.5% change in the dependent ‘Y’ (Gillespie, 2007). On the contrary, $|E| = 2$ (implying an elastic relationship) means that the percentage change in the dependent variable is twice the percentage change in the explanatory variable.

The economic importance of different variables (e.g. in terms of leverage, corporate governance and corruption) can be assessed through their elasticities. We focus in particular on inelastic relationships, for in these cases small changes in one variable may have large effects on another. Such inelastic relationships are found widely in the literature: an energy industry related example is the demand for residential electricity demand discussed by Wang and Jain (2003). In their case, a one percent change in electric price reduces the demand for electricity by 0.79 percent (implying an inelastic relationship). In another example, relating to the company finance decision, Hovakimian et al. (2001) find that two important inelastic determinants of the debt versus equity decision are post stock returns (with an elasticity of 0.122) and the market-to-book ratio (with an elasticity of 0.105).

This thesis also uncovers a number of important inelastic relationships. We find that, for instance, small changes in leverage can have large R&D effects (Chapter 3); small changes in corporate governance can have large effects on company valuation (Chapter 4); and corruption effect on FDI inflows (Chapter 5).

Summary remarks on theoretical background

This chapter on theoretical background provides an explanation of the applied panel data specifications and estimation techniques on which we depend in the empirical examination undertaken in subsequent chapters. Each of the empirical analyses is presented for the pooled OLS, the OLS with random and fixed effects controls, the first-difference after removing unobserved fixed effects, and elasticity. We also use a GMM estimator to address the dynamic specifications of the panel data after the inclusion of lagged dependent variables among selected regressors. Post-estimation tests indicating the validity of the results are considered. The joint significance of the inclusion of explanatory variables, the significance of year control, and selection between OLS-RE and OLS-FE are examined. The dynamic panel data post-estimation tests are presented using weak instruments and overidentifying restrictions when applicable.

CHAPTER 3

3. Financing innovation: implications for European firms in the energy sector

Abstract

This chapter examines whether and how the measures of corporate leverage, such as the ratio of total debt to total assets and operating income availability, can stimulate financing for research & development (R&D) in the European energy sector. It is argued that financing innovations not only depend on controlling for tax payments as tax shields and firm operating age as a proxy for financing opportunities, but also on whether the energy company is privately owned, and whether it is located in an old or new-EU country. Using firm-level data for 1995–2007 from 24 European countries, we find that the leverage level and operating income availability have stimulated R&D among major energy firms: utilities as well as oil and gas producers. We found that, in the context of facilitating R&D activities, leverage is more important for the oil and gas sector, while operating income is more important for utilities.

3.1. Introduction

Investment in research and development (R&D) is of paramount importance for any economy because technological innovation is a key driver of economic growth (Solow, 1957). In general, the R&D literature has assumed that research activities positively influence firm value (Solow, 1957; Myers, 1977; Rajan and Zingales, 1995). However, important externalities are involved in financing for R&D. The primary output of R&D investment is to generate knowledge about new goods and services, and this knowledge cannot be kept secret. Thus, the benefits of research are enjoyed not only by the investing firm but also by other companies operating in the industry. Hence, the latter may act as an impediment to the financing of research and innovation. Indeed, Balakrishnan and Fox (1993) and Mulder (2008) argued that investment in energy does not pay off in innovation activities and requires substantial subsidization. In addition, it has been stressed that R&D investors exhibit great uncertainty in decision-making. However, amidst concerns about the security of energy supplies and calls for greater environmental protection, innovation in energy technology is becoming increasingly important to meet the growing demand for energy. At the same time, our knowledge about financing innovation in the energy industry remains rather limited. This chapter is an attempt to bridge the gap in the literature by assessing the relationship between general corporate leverage levels and innovation activities in the European energy industry.

A limited amount of literature exists on this topic, especially regarding the strategic management of firms:

- The existing research has shown that a higher degree of R&D intensity is associated with not only better firm value but also reduced leverage because R&D investment creates intangible assets, which cannot be used as collateral (Bhagat and Welch, 1995; Rajan and Zingales, 1995). Nevertheless, debt level is found to be an important predictor of R&D, because it highlights the strategic importance of innovation for firm development.
- Vincente-Lorente (2001) further argued that R&D investments characterised by a high degree of specificity are associated with reduced leverage; however, those R&D activities that are less specific are more capable of supporting debt. One could also conceive a reverse causation in that minimal leverage could be a priority for firms that compete on the basis of innovation (see O'Brien, 2002). This is because minimal leverage

ensures: (i) continuous uninterrupted investment in R&D; (ii) the funds necessary to launch new products when needed; and (iii) the firm's ability to expand its knowledge base through acquisition when it is potentially beneficial to do so.

- Finally, much of the existing literature consists of country-level empirical studies (Bhagat and Welch, 1995; Rajan and Zingales, 1995). There are only a few firm-level studies on the energy industry (see Balakrishnan and Fox, 1993 on the mining sector; Mulder, 2008 on the wind energy sector).
- Thus, our analysis contributes to the limited literature on financing innovation in the energy industry. Furthermore, we highlight sectoral differences between the two major European energy sectors: utilities and oil and gas producers.

By considering different strands in the existing literature and the growing importance of expanding the energy industry, the present chapter develops and examines the following central hypothesis:

- Reduced leverage corresponds to more R&D at energy companies. This hypothesis highlights the trade-off between lower and higher levels of debt in the company in relation to R&D spending (as increased leverage may lead to overwhelming financial liabilities and depress R&D investments).

Furthermore, we extend the research literature with an additional hypothesis:

- Operating income complements the effects of leverage on R&D in energy companies.

  It may be argued that differences in the financing of innovation could result from the availability of operating profit to support the finance of innovation (*see e.g.,* Stiglitz and Weiss, 1981; Bhagat and Welch, 1995; and Brown and Petersen, 2011). The importance of operating income for financing R&D emerges from the notion that when it is more difficult to obtain leverage from financing institutions, when investors cannot measure the quality of future opportunities and when it is challenging to predict future cash flow, it companies may use operating income as a buffer to finance R&D expenditures. Further, the research on operating income appears to suggest that greater stability in the operating environment would allow the firm's management more strategic options in terms of raising R&D expenditure, should it be required.

We also control for the commonly discussed measures known to influence R&D activity: tax shields to offset R&D expenses, liquidity, firm operating age as a measure of the company's likely long-term viability, firm ownership status according to the private versus state ownership effect on financing innovation, and EU integration (Gros and Mortensen, 2004; Ayygari et al., 2007; Hadlock and Pierce, 2009; Brown and Petersen, 2011). Section 3.2 of this chapter develops the related hypotheses for the ultimate inclusion of these control measures.

Our results demonstrate that the relationship among corporate leverage level, operating income and R&D activities is consistent through the use of various control factors: both reduced leverage and operating availability help to finance innovation among energy companies:

- First, the level of R&D activity is dependent on the level of leverage—although R&D in both sectors increases with debt, it does so at a decreasing rate. This means too much leverage may overwhelm the financial attractiveness of the company.
- Second, operating income availability is an important financing factor for utilities but not for oil and gas companies. Operating income availability is an important financial boost for 'younger' companies as compared to established energy firms.
- Third, we also determined that privately owned companies as compared to state-owned firms can more easily secure financing for innovation. This is due to the competition incentives private companies face in any sector of the market. In this respect, state-owned companies are often large monopolistic giants and therefore lack competition incentives, which in turn can stagnate R&D.
- Fourth, access to financing for innovation is contingent for firms in established EU countries: firms in the new EU states (that have joined since 2004) rely solely on operating income as a source of financing for R&D. The companies in established EU countries are able to use financial incentives more effectively; such countries also have more credible lending institutions. For instance, we find that tax incentives are significant for energy companies in the old-EU countries but not in new EU member countries.

Overall, our estimates show that 'younger' energy companies and those from newly established EU countries require substantial help and the introduction of various incentive mechanisms in order to become active in R&D. This is especially important because innovation in the energy sector is also a key goal for EU energy policy, which aims to improve energy efficiency, reduce energy dependence and achieve sustainable environmental development. We test the robustness of these results against various R&D and leverage specifications.

Our main data source is the OSIRIS database, which consists of detailed balance sheets, profit and loss accounts, and cash flow data for virtually all existing and currently operating energy-industry firms in 24 European countries, including both old and new member countries. We concentrate on the period from 1995–2007, for which we had the most observations.

After various experiments, we selected commonly known R&D proxies, defined as the ratio of R&D expenditure to total assets and of R&D expenditure to sales (*see e.g.*, Bhagat and Welch, 1995). To determine corporate leverage, we applied the general total debt to the total assets ratio and applied total liabilities to total assets ratios (*see e.g.*, Rajan and Zingales, 1995; Cole, 2008). While we focus on energy sector firms, we classify the energy industry firms into two sectors (utilities and oil and gas producers) that comprise more than 80% of all energy firms in our sample. We argue that this distinction is important, in that these two groups of firms are rather different in their financing patterns, as borne out by our analysis (see the discussion in Section 3).

We operate with the panel data analysis and present the relevant estimation specifications. In particular, we start with pooled-OLS and concentrate on the validity of such specifications as OLS with random and fixed effects and selection between the two. We also use an OLS first-difference estimator and discuss the results using elasticities. The GMM estimator is employed to control for inclusion of the lagged dependent variable among the regressors. Heteroscedasticity is controlled with White's standard errors. We use various post-estimation tests such as the joint test to determine the significance of the explanatory variables, the years test for the significance of time control, Hausman's test for selection between OLS with random or fixed effects and the weak-instruments test for the GMM estimator.

The study is developed as follows. Section 3.2 develops hypotheses that examine financing for innovation. Section 3.3 describes the data for R&D, leverage and operating income measures, control variables, and distinguishes the two major energy sectors. Section 3.4 explains the methodology and model used to assess financing for innovation. Section 3.5 analyses the results. Finally, Section 3.6 concludes and provides suggestions for further research.

3.2. Hypotheses

While our research builds on the existing literature to explore the relationship between corporate leverage and R&D in European energy sector companies, we extend the relevant literature by establishing two hypotheses. The main null hypothesis is that reduced leverage may correspond to higher levels of R&D. The second hypothesis is that operating income may be used as a buffer to leverage financing for R&D.

3.2.1. H1: Lower levels of debt correspond to higher levels of R&D

Examination of the relationship between the capital structure of a firm and its propensity to engage in R&D has seen the focus of much research in the past. In an early investigation, Myers (1977) considered R&D as the ultimate future growth opportunity for the firm. The certainty of the intangibility of the R&D assets to pay off the associated borrowing cost to lenders and relatively lower cost of raising external debt (compared to profits used internally) impacts the availability of leverage with respect to financing innovations, and so the level of R&D itself. This implies that R&D depends on discretionary investments, which in turn suggests that firms that are highly leveraged would tend to reduce their R&D expenditure because, as a matter of priority, the firm's generated resources should be allocated towards making the principal and interest payments. Following that, with some exceptions, the observed studies find mostly negative effects of leverage for innovation activities, which we will discuss in this subsection.

Furthermore, most of the studies cover country-level data for each firm examined (*e.g.,* Bhagat and Welch, 1995; Rajan and Zingales, 1995) and only limited research concerning energy industries (e.g., Balakrishnan and Fox, 1993 examined mining industries; Mulder, 2008 studied the wind energy sector). To our knowledge, there is no study controlling for the impact of leverage on R&D among European energy companies. This gap in the literature was used to establish our central hypothesis: lower levels of debt correspond to higher levels of R&D. Conversely, increased leverage may decrease R&D.

Those studies finding negative effects of leverage for R&D discuss that the relationship is not straightforward. For instance, Balakrishnan and Fox (1993) found leverage to be negatively correlated with R&D expenditure among 295 mining and manufacturing firms. However, Bhagat and Welch (1995) found that the relationship varied among countries by conducting an empirical study on firms located in various OECD nations. They found that leverage from the previous year was negatively correlated with present-year R&D expenditures in US firms. This correlation was positive in the case of Japanese firms. They explain that US companies preferred to safeguard R&D investments by controlling the amount of debt within the company. Bhagat and Welch (1995) indicated that their results may be biased due to inherently different levels of leverage across OECD nations. Notwithstanding, the results of Rajan and Zingales (1995) and Booth et al. (2001) suggest that the capital structures of firms across developed nations may be more similar to one another than suspected, which requires further exploration of any possible common drivers.

A separate approach to the relationship between capital structure and R&D expenditure has been taken from the strategic management discipline. Simerly and Li (2000) considered the case of environmental dynamism, measured in terms of the variability of the industry value (e.g., returns on assets) of shipments. They studied a situation where R&D may be a critical factor for differentiating between one firm and the next. They found that capital structure affects the way that the firm relates to the R&D environment by adjusting the corporate governance structure of the firm. In cases of high leverage, control over the company takes on an external focus, which suggests that, for firms with a highly dynamic environment, an increase in leverage would tend to lead to a decrease in R&D expenditure.

Another discussion on attracting financing for R&D using state subsidies and incentives was highlighted by Mulder (2008), who found that investments in energy, and particularly the renewables sector, do not pay off innovation activities because of the high capital cost involved. He highlighted the issue with the capital-intensive energy sector, stressing R&D investors' uncertainty in decision-making with regard to future returns.

The findings of the subsequent literature highlighted a common observation: the negative relationship between leverage and R&D arises because companies tend not to overburden themselves with debt liability. This is because it is difficult to estimate future incomes based on capital-intensive R&D activities. Thus, the level of R&D activity would depend on the level of leverage. Therefore, the following hypothesis was developed:

Lower levels of debt correspond to higher levels of R&D. In order to explore the role of financing for R&D in this relationship, we examine the effect of the internal financing source—operating income for R&D.

3.2.2. H2: Operating income complements the effects of leverage on R&D

The importance of operating income for financing R&D emerges from the notion that when it is more difficult to obtain leverage from financing institutions, when investors cannot measure the quality of future opportunities and when it is challenging to predict future cash flows, it is likely that the company may use operating income as a buffer to finance R&D expenditure. Thus, we explore how operating income may complement the effect of leverage on R&D.

As indicated by Simerly and Li (2000), the effects of capital structure on R&D differ depending on the dynamism of the environment in which the firm operates. Simerly and Li (2000) further elaborated that in more stable environments, the company may increase its leverage because debt financing could be cheaper for the company whereas equity financing may be the better option due to the alignment between the interests of management and shareholders. This extends a thread of the argument developed by Stiglitz and Weiss (1981), who viewed the choice between equity and debt financing in terms of the principal-agent problem. In heavily leveraged firms, the management of the company tends to have a heavy risk imposed upon them. This is not a condition that is conducive for risk-taking behaviour such as that manifested by increasing R&D expenditures. Given these asymmetric information considerations, internally generated income may be the likely source of R&D capital. Similarly, Bhagat and Welch (1995) argued that the extent to which capital investments and R&D expenditures have similar determinants, operating income would correlate positively with future R&D, where operating income variability is defined using net income plus depreciation as a percentage of total assets.

Myers and Majluf (1984) have argued that when investors cannot distinguish between high-quality and low-quality future opportunities, managers with good information are more likely to finance projects internally, less likely to raise outside debt, and less likely to raise outside equity. The resulting adverse selection raises the cost of external equity compared with internal finance. Thus a company may use operating income flows to finance required developments.

Related to the uncertainty of income availability, Loof and Heshmati (2006) found that uncertainty about a firm’s income (measured as the variance of sales) may influence its optimal leverage level negatively. The more variable a firm’s operating income is, the greater the risk that the firm will be unable to cover its interest payments and the higher the probability of bankruptcy. Similar research has also been undertaken more recently by Brown and Petersen (2011), who found that firms, particularly young firms, use cash as a buffer to smooth their cash outflows due to R&D expenditure by building cash reserves when financing is easily obtained and drawing down on those cash reserves when financing is more difficult to get. Although Brown and Petersen (2011) discuss the R&D smoothing effect in terms of equity financing, the research appears to suggest that greater stability in the operating environment would allow the firm’s management more strategic options in terms of raising R&D expenditure, should it be required. In other words, in less competitive environments, management would be able to more accurately predict the firm's cash flow sources and needs and could therefore be more confident in undertaking more risky activities such as R&D.

Therefore that not only must the direct relationship between leverage and R&D be understood, but it also it is very likely that operating income influences R&D as well. This means that the availability of operating income (as a ratio of total assets) may alter the effect of leverage on R&D. Thus, the following hypothesis is established:

- Operating income complements the effects of leverage on R&D.

3.3. Data

Data for the analysis were obtained from the OSIRIS firm-level dataset for 24 European countries, including both old and new member states[1]. The database holds necessary information for the period from 1984–2008 on more than 250 firms in EU countries. Given the emergence of new member states in addition to the regulatory changes in Europe and data availability, we focus on the period from 1995–2007, for which we have the maximum number of observations. The total company sample has increased consistently over time from 73 to 261 firms. Although the number of observations has increased over the study period, certain data are still lacking. This means that the estimation sample is likely to explain innovation activities only partially. This important data caveat is discussed in the results section along with the findings.

In order to understand corporate financing behaviour in the energy industry, it is also important to classify companies into relevant sectors. Different industry classifications are available in the OSIRIS database (e.g., NAIC 2007; GICS code; Industry Classification Benchmark; Financial Times Industry Class; US SIC code(s); NAICS 2007 code(s); and NACE Rev. classification codes). For our data analysis, we have focused on the Industry Classification Benchmark (ICB). Using the ICB, we identify 11 subsectors within the energy industry; among these, utilities and oil and gas producers represent the largest sectors. Firms belonging to these two sectors account for more than 80% of our observations, and hence our analysis focuses on them. Furthermore, utilities are represented by a higher number of companies than oil and gas producers, although the

[1] The 24 European countries covered in the study are Austria, Belgium, Cyprus, Czech Republic, Germany, Denmark, Estonia, Spain, Finland, France, UK, Greece, Hungary, Ireland, Italy, Lithuania, Luxemburg, Latvia, Netherlands, Poland, Portugal, Romania, Sweden and Slovakia.

difference diminishes over time. Table 3.1 highlights the heterogeneity among these sectors and therefore the need to differentiate them when analysing financing and innovation.

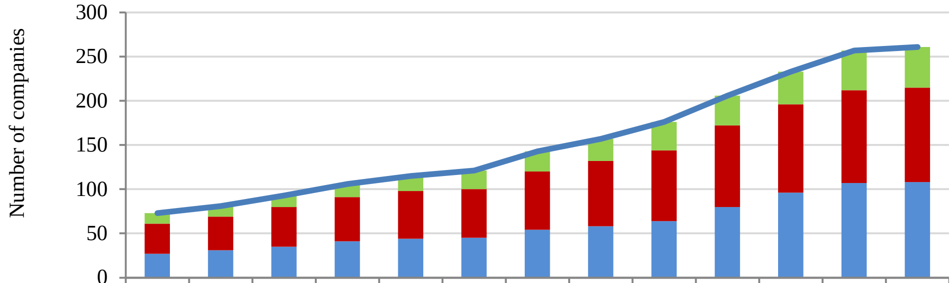
Figure 3.1 presents the distribution of energy firms between the major energy sectors and other sectors over the observed time period. The aim of this chapter is to analyse the European energy companies; we do not pursue analysis of the individual countries and companies. WE are aware that the majority of companies are located in the UK, France, Italy, Spain and Germany (Figure 3.2). Further research including country-level analysis is planned for the future.

Table 3.1: Industry classification

Industry Classification Benchmark (2007)	Nr. of firms	%
Two largest sectors:		
Oil and gas producers	108	41.4%
Utilities	107	41.0%
Other sectors:	46	17.6%
Industrial	*10*	*3.8%*
Basic resources	*10*	*3.8%*
Oil equipment, services and distribution	*8*	*3.1%*
Financial services & investment instruments	*6*	*2.3%*
Basic materials	*4*	*1.5%*
Industrial engineering	*3*	*1.1%*
Construction & materials	*2*	*0.8%*
Retail	*2*	*0.8%*
Technology	*1*	*0.4%*
Total	**261**	**100.0%**

We present the company distribution for 2007. The Industry Classification Benchmark (ICB) was accessed through the OSIRIS database. Note that firms engaged in providing utilities or producing oil and gas constitute more than 80% of our observations. Our analysis therefore focuses on these two sectors.

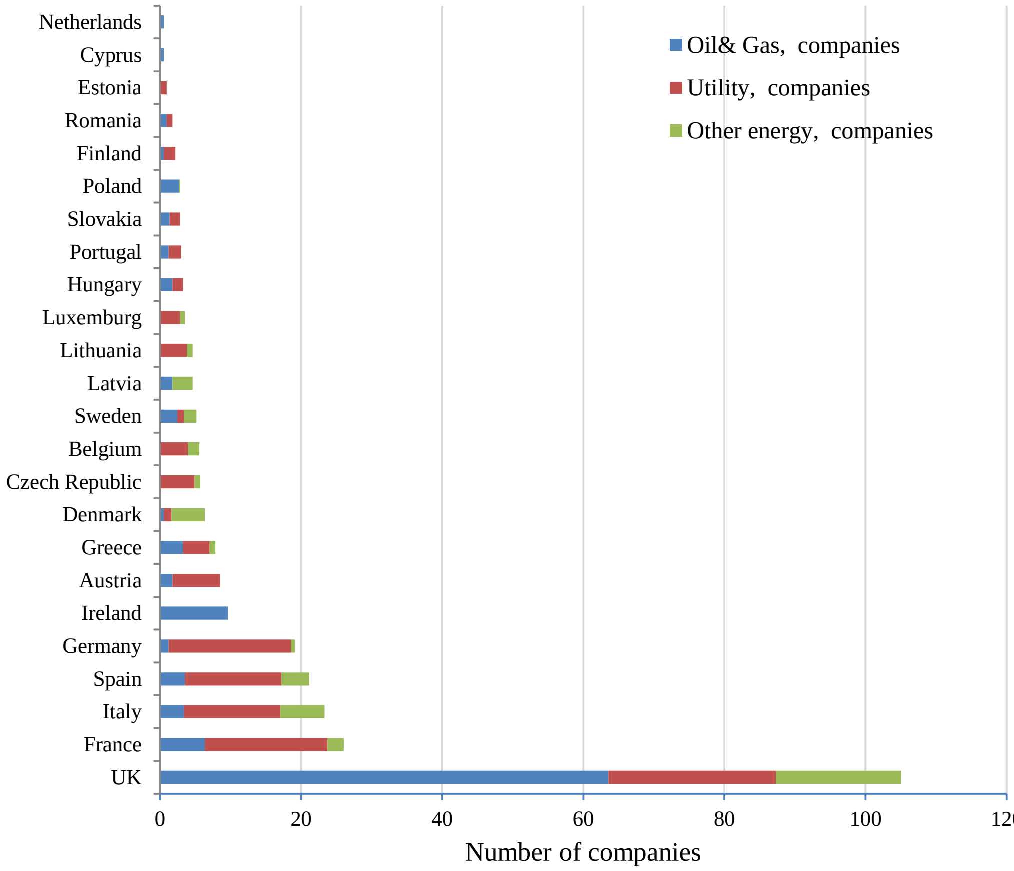
Figure 3.1: Distribution of energy sector companies, 1995–2007



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Other energy companies	12	12	13	15	17	21	23	25	32	34	37	45	46
Utilities	34	38	45	50	54	55	66	74	80	92	100	105	107
Oil& Gas	27	31	35	41	44	45	54	58	64	80	96	107	108
Total energy companies	73	81	93	106	115	121	143	157	176	206	233	257	261

Company observations were obtained from OSIRIS firm-level data for a number of European countries including both old and new member states. Given the emergence of new member states as well as the regulatory changes in Europe and data availability, we focused on the period from 1995–2007, for which we have the maximum number of observations. There is a clear increase in the number of emerging companies across Europe, from 73 in 1995 to 261 companies in 2007.

Figure 3.2: Distribution of energy sector companies by country in 2007



In this figure, we show the distribution of utilities, oil and gas companies among countries included in the OSIRIS database. In our analysis, we refer to the general European area, which includes 24 countries (old and new members) and the TOP5 countries: the UK (105 firms), France (26 firms), Italy (23 firms), Spain (21 firms) and Germany (19 firms).

3.3.1. Dependent variable (R&D)

In examining the effect of leverage on R&D, related studies have used various innovation measures, depending on the data available for the selected country samples. It is important to select the most appropriate R&D measure, as this will constitute the dependent variable in our central hypothesis. With regard to R&D usage, the most common measures are ratios of R&D to total assets and R&D to sales. For instance, Bhagat and Welch (1995) used R&D expenditure to total assets, as this ratio represents costs incurred for the development of new products and services. However, Balakrishnan and Fox (1993) used ratios of R&D and advertising expenditure, respectively, to net sales. The 'innovation expenditure to net sales' ratio is dictated by the use of the 'net sales proportion' to allow control for non-debt tax shields. Instead of measuring the level of R&D, Cole (2008) measured the ratio of tangible assets to total assets. Booth et al. (2001) was not able to measure R&D in his study, as the selected data source did not provide information on intangible assets. However, studies by Rajan and Zingales (1995), Simerly and Li (2000), and Mulder (2008) discussed the importance of innovation as compared to leverage but did not investigate R&D due to the lack of available data for the selected firms and countries.

In addition to the ratios of R&D expenditure to total assets and net sales in firm-level studies, other country-level studies included the number of patents granted, the R&D to GDP ratio and R&D defined as an investment in knowledge. We do not include these additional country-level R&D proxies in the empirical estimation, as these do not directly relate to our energy firm sample. Appendix 3.B discusses these additional R&D proxies. Taking commonly used firm-level R&D measures, we concentrate on both R&D expenditure to total assets and R&D expenditure to net sales ratios.. The R&D measures are derived from balance sheets obtained from the OSIRIS database.

We applied both measures in our empirical analysis. It is expected that because the energy sector is a capital-intensive industry, the level of R&D expenditure on intangible assets as compared to total assets is a more appropriate measure than the sales ratio. We also used as the number of patents registered, the ratio of R&D to GDP and the ratio of R&D to employment, but did not find these significant in our sample. Appendix 3.B and 3.C provide details about these additional R&D proxies. Table 3.2 provides descriptive statistics for R&D in both sectors and compares these values with those obtained for the energy sector as a whole. The energy industry R&D maintained at a 10% level seems to be driven by R&D in the oil and gas sector (16%), whereas utility companies spend on average half this amount (7%) on innovation.

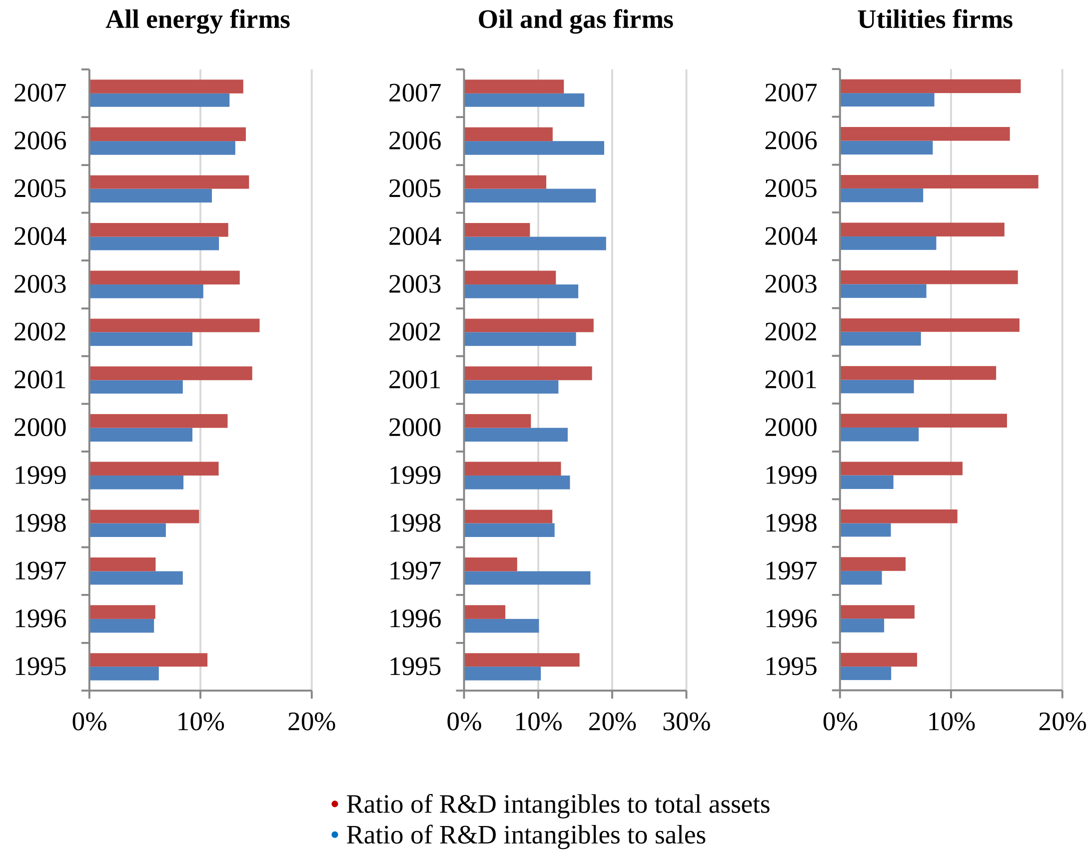
Table 3.2: Means and standard deviation of selected sectoral R&D, 1995–2007

	Utilities	Oil and gas producers	Energy sector
R&D intangibles to total assets:			
Mean	0.0708	0.1590	0.1030
Std. dev.	0.1010	0.2328	0.1698
R&D intangibles to total sales:			
Mean	0.1422	0.1222	0.1282
Std. dev.	0.1911	0.1929	0.1893

R&D intangibles are defined as the ratio of expenditures to total assets. We adjust the ratio by including ratios of 0 to 1 only. The R&D definition is based on the methodology used by Bhagat and Welch (1995).

We do not perform an empirical estimation for each country because of the small number of observed companies in many countries; instead, we provide an overall estimation for all countries in the sample. However, using the average R&D expenditure values by countries and over time, we show that the countries differ in terms of innovation. Figure 3.3 illustrates that, for instance, the ratio of R&D to total assets does not exceed 15% (Ireland) in the oil and gas sector; in the majority of companies, the amount is lower than 7%. The ratio of R&D to total asset spending among utilities firms is about the same as for the study sample as a whole and does not exceed 16% (Belgium). Furthermore, European energy firms tend to spend different proportions of the company's assets on R&D over time. At the aggregated EU level, companies tend to spend more on innovation every other year. There is a significant year-on-year increase in R&D spending in each of the major energy sectors, which drives the general industry level. R&D expenditure is still relatively small and only in rare years has exceeded 10% of total assets, but in 2007, this ratio was approximately twice that of the 1995 figures in both utilities and the oil and gas sectors. This means that R&D has become an important instrument in the energy sector and that innovation is likely to receive increased attention from energy firms in the future.

Figure 3.3: Distribution of R&D by year, 1995–2007



This figure represents the distribution of R&D among the firms in Europe. The yearly level charts show that at R&D activities tend to increase in Europe as a whole. The data were obtained from the OSIRIS firm-level database. The R&D proxies are defined in Section 3.3.1.

3.3.2. Regression measures

We have defined two regression measures according to our hypotheses. These are leverage and operating income.

Leverage

In examining the effect of leverage on R&D, related studies used various financing measures, depending on the data available for the selected country samples. The main issue raised by the studies is how to define leverage. The observed studies commonly refer to both book ratios (based on balance sheet data) and market ratios (considered when firms are registered on stock markets). Our data sample covers both non-listed and listed companies. However, the firm data obtained from the OSIRIS database does not present consistent market-type ratios, so we concentrated on book ratios. The most commonly used book-type leverage measures are total debt to total assets and total liabilities to total assets ratios. These measures represent general leverage within companies. The difference in comparing debt vs. liabilities to total assets is that the first comparison includes both short-term and long-term debt, while the latter ratio is viewed as a proxy for what is left for shareholders in case of liquidation (Rajan and Zingales, 1995). Further, both Booth et al. (2001) and Cole (2008) explained that these leverage proxies are viewed as an essential way of doing business with controls for both current and long-term liabilities. More importantly, these measures reflect the assessment of the amount of borrowed long-term debt, which represents, for instance, plants, buildings or land, as well as business loans. These significantly affect liquidation cost, and thus companies with many illiquid assets should be financed with relatively less debt. Similarly, Balakrishnan and Fox (1993), Bhagat and Welch (1995) and Simerly and Li (2000) used long-term and short-term debt to assets ratios. Mulder (2008) discussed the implications of debt and R&D measures but has not used these in estimations. Instead, he selected tax incentives, turbine sales prices and interest rates as explanatory measures to investigate the attraction of investments in wind energy.

Amongst other possible measures of capital structure, Rajan and Zingales (1995), and later Simerly and Li (2000) and Booth et al. (2001), used long-term book-debt ratios and long-term market debt ratios. However, the data necessary for these ratios is only available for those companies registered on the stock exchange and further limited by the availability of stock data. Rajan and Zingales (1995) showed that another way to measure leverage is to determine total debt to net assets, where net assets are total assets less accounts payable and other liabilities. Although this measure is not influenced by trade credit, it is affected by factors that may have nothing to do with financing. For example, assets held against pension liabilities may decrease this measure of leverage.

When considering the availability of various leverage measures and that we deal with book type ratios, in our study we refer to two common leverage proxies, denoted as total debt to total assets and total liabilities to total assets ratios. A detailed explanation of other leverage proxies and their use in the literature is provided in Section 3.2. Table 3.3 shows selected leverage measure descriptive statistics for two major energy sectors and compares them with the general energy industry.

Table 3.3: Means and standard deviation of selected leverage proxies, 1995–2007

	Utilities	Oil and gas producers	Energy sector
Total debt to total assets:			
Mean	0.2649	0.1836	0.2411
Std. dev.	0.1829	0.3501	0.1779
Total liabilities to total assets:			
Mean	0.6021	0.3501	0.4905
Std. dev.	0.2051	0.2411	0.2532

We measure corporate leverage as the ratio of total debt to total assets. These ratios are also used by Rajan and Zingales (1995) and Booth et al. (2001).

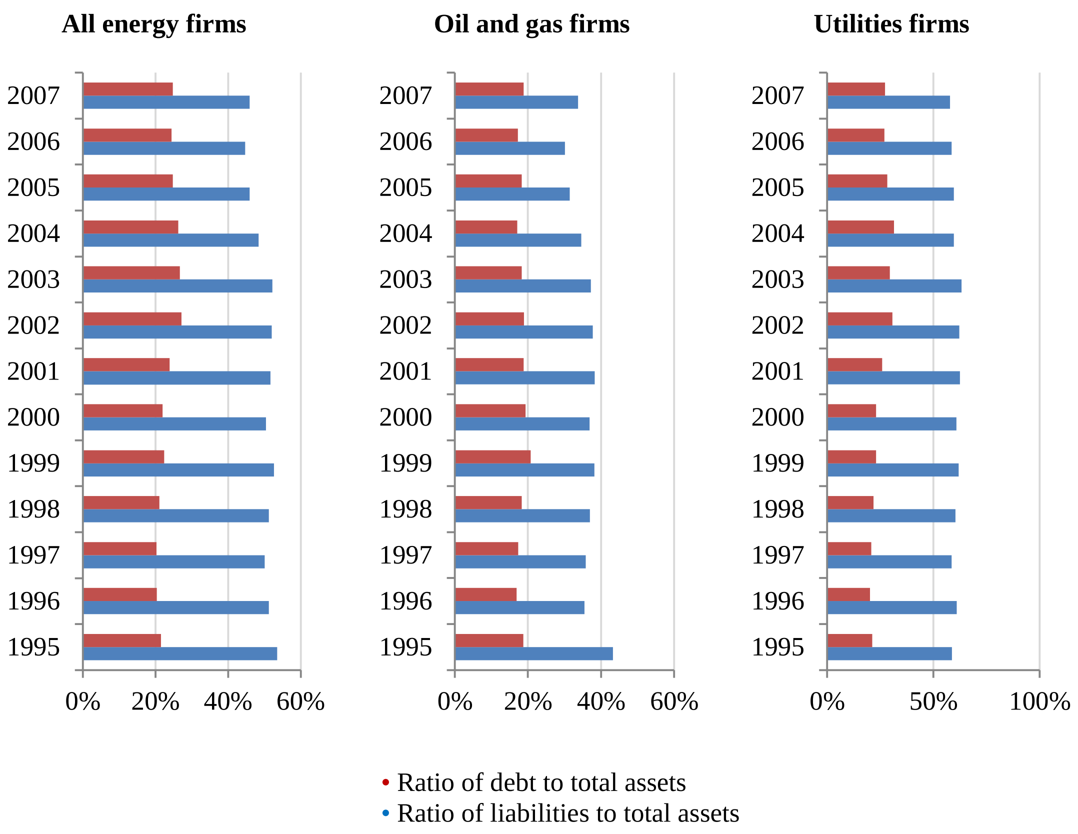
The selected leverage measures have been used widely in the existing literature and represent the potential risk of a company. A ratio level between 0 and 0.5 indicates that a company tends to finance on the balance sheet, whereas a ratio greater than 0.5 shows that company is likely to rely more on external funds. For instance, the average ratio of 26% for utilities (Table 3.3) means that the creditors have put up EUR 0.26 for every EUR 1 the company owners have put in; that is, the debt of a company is less than its assets. The leverage measures are derived from balance sheets obtained from the OSIRIS database.

The utility firms tend to have much higher average debt (26% for 'total assets'-based and 60% for 'total liabilities'-based) compared with oil and gas producers (19%). We also compared the sample averages with those obtained by Rajan and Zingales (1995) and Booth et al. (2001)[2]. In agreement with Rajan and Zingales (1995), our study finds that the energy industry has the same average debt ratio (24%) as that calculated for the G-7 countries for the period from 1987–1991 (23%). Although the overall leverage data are similar to those in the existing literature, the comparison should be treated with caution, as different countries, firms and time periods were used for these analyses.

Figure 3.4 highlights that the debt level varies, and it is difficult to determine any pronounced tendency when comparing major energy sectors. However, when looking at the aggregated EU level year-by-year, the leverage in oil and gas companies is at about the same level (a 19% debt-to-total assets ratio), whereas the utilities tend to become more leveraged over time (e.g., an increase to 27% in 2007 from 21% in 1995). The increase in utilities leveraging may demonstrate the development of these companies in the EU territory as the energy sector of each European country has become more open to immigrants and therefore has required additional investments for financing innovation.

[2] Note that the studies by both Rajan and Zingales (1995) and Booth et al. (2001) have only four countries in common with our country sample (Germany, France, the UK and Italy). However, these countries provide the majority of firm data used for our research.

Figure 3.4: Distribution of Leverage by years, 1995–2007



This figure represents the distribution of the two alternative leverage measures among the firms in the European countries. The yearly level charts show that leverage in oil and gas firms tends not to change over time as compared to increased levels among the utilities sector. The data were obtained from the OSIRIS firm-level database. The leverage proxies are defined in Section 3.3.2.

Operating income

According to Loof and Heshmati (2006) and Brown and Petersen (2011), operating income should be significant for companies having difficulties in obtaining leverage for R&D activities. That is, financing innovation with operating income may provide an additional boost when the leverage available is not sufficient. We used the same operational income measure applied by Bhagat and Welch (1995), which is the sum of net income and depreciation as a proportion of total assets. Table 3.4 shows that in our sample, the average ratio of operating income to total assets is higher for oil and gas producers at 0.17 (average operating income is EUR 635,000). Utilities, at 0.15 (average operating income is EUR 427,000), are similar to the energy industry average level of 0.15 (average operating income is EUR 444,000).

Table 3.4: Means and standard deviation of operating income, 1995–2007

	Utilities	Oil and gas producers	Energy sector
Operating income, millions (EUR):			
Mean	426,979	635,062	444,184
Std. dev.	1,239,971	3,310,031	2,282,136
Ratio of operating income to total assets:			
Mean	0.1542	0.1017	0.2197
Std. dev.	0.1849	0.0335	0.2622

Operating income denotes the net income plus depreciation as a percentage of total assets, following Bhagat and Welch (1995).

3.3.3. Control measures

It may be argued that differences in the financing of innovation could result from other factors. These may consist of tax shields to offset R&D expenses, liquidity, firm operating age as a measure of the company's long-term viability, firm ownership status according to the private versus state ownership effect on financing innovation, and EU integration. These control variables are obtained from the balance sheets, and similar to the data on R&D and leverage, were extracted from the OSIRIS database. The number of years for which the country has been a member of the EU is used as a proxy for EU integration[3].

Tax shields

We refer to the significance of an effect of tax shields on financing R&D because increasing leverage is desirable due to the tax shield on debt that can accrue to the company (Modigliani and Miller, 1958). It is a common finding in the literature that tax existence positively affects leverage in the company; however, tax issues related to financing opportunities are complicated by the fact that countries frequently allow companies undertaking R&D activities to claim tax credits, which emerge from both non-debt (refers to the depreciation of assets) and debt tax shields.

Bradley, Greg and Han Kim (1984) investigated the relationship between R&D on one hand and both non-debt tax shields and debt tax shields on the other. They found that R&D tax shields should not be considered as a substitute for debt tax shields due to the perverse relationship between the level of R&D expenditure and R&D tax shields. There was a significant positive relationship between leverage and the level of non-tax shields. Bradley, Greg and Han Kim (1984) postulated that this was because non-debt tax shields

[3] The EU membership of a country is denoted by its official joining year, as obtained from http://www.eucountrylist.com

represent the securability of the firm's assets, where firms with more securable assets tend to have higher leverage ratios. This is supported by Loof and Heshmati (2006) who found that, using the ratio of depreciation to total assets in order to measure the existence of non-debt tax shields, suggested a negative relationship between a tax shield and the leverage level in highly leveraged countries like Sweden. However, the measure was insignificant in low-leverage companies located in the UK and US.

In a more recent study completed by Bhagat and Welch (1995), R&D expenditure follows the value of related tax subsidies, which increase with a firm's marginal tax rate. They find mixed evidence of the tax shield fostering R&D. The authors used total taxes payable to total assets to control for the tax shied level. The results among countries differ according to the degree of tax legislation. According to Bhagat and Welch (1995), the most complicated R&D-related tax incentives are to be found in Japan, whereas in other countries, including those in Europe, R&D tends to be subsidized by various forms of tax incentives, *e.g.*, government grants which offset tax levels. In contrast, Hines Jr. (1993) found that R&D activities were fairly inelastic to changes in R&D tax incentives at US firms. That is to say those firms in the US tended to maintain a pattern of R&D spending somewhat independently of the changes in tax incentives for R&D activity.

Cole (2008) considered the optimal balance between tax-deductible expenses in relation to R&D among privately held US manufacturing firms. He found that the balance of tax shields for R&D should be at a level such that the marginal benefit of the shield is not greater than the marginal cost associated with the probability of financial distress of acquiring the leverage.

These papers argue that there should be a relationship between the level of tax shields and leverage, where increased tax rates lead to higher recoverable tax shields, thus increasing the incentive to increase leverage and increasing the incentive to engage in R&D. With regard to the quantification of tax shields, we used the ratio of total taxes payable by the firm to total assets (Bhagat and Welch, 1995). The descriptive statistics in Table 3.5 show that the average tax ratio for both major sectors and the energy industry on average does not exceed 0.01 and may be only marginally higher in oil and gas production firms.

Table 3.5: Means and standard deviations of selected tax proxies, 1995–2007

	Utilities	Oil and gas producers	Energy sector
Tax to total assets:			
Mean	0.0153	0.0174	0.0152
Std. dev.	0.0185	0.0335	0.0262

The ratio of tax payments to total assets is the ratio of total taxes payable by the company to total assets, according to Bhagat and Welch (1995).

Liquidity

The presence of liquidity has a mixed impact on R&D activity. The liquidity issue in relation to R&D has been widely discussed in the existing literature. The common ground is that liquidity provides advantages in the form of unexpected short-term investment opportunities without the need to raise new capital (e.g., Cole, 2008). This may suggest that those companies with greater liquidity possess a lower probability of financial distress and hence are likely to attract investments towards innovations when they are needed. Nevertheless, Rajan and Zingales (1995) indicated that it is difficult to establish an effective level of liquidity, as each industry and even every company faces unique business challenges. Explicitly, Hall (2002) and Bougheas et al. (2002) found strong evidence for the importance of liquidity among industrial companies and demonstrated the presence of liquidity constraints for R&D-oriented companies. Further, Sarmistha and Driffield (2008) highlighted that a company should be concerned with its level of liquidity, as otherwise it might be caught in a liquidity attack (i.e., having short-term debt but long-term assets).

With regard to the observed sample of energy companies, we operate with two common liquidity proxies: the current ratio and the liquidity ratio (both are measures of current assets, but the liquidity ratio excludes stock from the current assets). The descriptive statistics in Table 3.6 indicate that both ratios are high in both major energy sectors, where oil and gas producers seem to dominate the energy market. The high average ratio values (greater than 1) indicate that energy companies are fully covered against potential liquidity.

Table 3.6: Means and standard deviations for selected liquidity proxies, 1995–2007

	Utilities	Oil and gas producers	Energy sector
Current ratio (current assets to current liabilities):			
Mean	3.56	5.29	4.24
Std. dev.	31.32	13.88	23.17
Liquidity ratio (current assets excl. stocks to current liabilities):			
Mean	3.92	5.30	4.52
Std. dev.	31.75	13.86	23.43

Liquidity measures are widely discussed in the related literature, e.g., Rajan and Zingales (1995), Hall (2002), Bougheas et al. (2002), and Sarmistha and Driffield (2008).

Firm age

Previous studies have found that firm age is a factor in surviving economic stress and business and market competition. These studies found that more mature companies have an advantage over younger firms. The firm's age was found to be especially important in capital-intensive industries (Audtretsch, 1991; Brown and Medoff, 2003). Therefore, the advantage of controlling for a firm's operating age is that it allows us to determine how the number of years in an industry reflects the ambient business conditions and, in our case, the ability to attract leverage for financing R&D.

Although firm age is known to positively affect company development, there is evidence that younger firms are more likely to introduce new products and new technology, upgrade existing product lines, open new plants, sign joint ventures, and bring in previously outsourced activities. However, older firms are more likely to discontinue products or close existing plants (Ayygari et al., 2007). In contrast to Ayygari et al. (2007), Hadlock and Pierce (2009) performed a more recent study that applied a qualitative index based on information disclosed by a large random sample of companies. They found that younger firms are affected by financial constraints, but more importantly, firm age and firm size (as total assets) were the two most important proxies observed by lending institutions that decided to provide financing opportunities. In another recent study, Brown and Petersen (2011) found that younger firms (those with operations for fewer than 15 years) face more financial constraints; they explained that more mature companies have more experience in the industry and thus garner more respect from lending institutions.

Thus, building on the mixed empirical findings that firm age may or may not facilitate financing decisions for R&D activities, we include the age of a firm as a regressor. For instance, Brown and Petersen (2011) define 'younger' companies as those with operational ages of less than 15 years; more ‘mature’ companies are those with more than 15 years of experience in operations (following Brown and Petersen, 2011). In our analysis, we control for the firm’s operational age through the use of various “age groups” (5, 10 and 20 years). We believe this would allow us to see the effect of firm age on financing innovation.

Table 3.7: Means and standard deviation of firm age, 1995–2007

	Utilities	Oil and gas producers	Energy sector
Firm age across the full period			
Mean	24	12	20
Std. dev.	36	25	34
Number of companies by operational age:			
101+ years	13	2	7
51-100 years	25	6	15
21-50 years	22	8	7
16-20 years	13	6	4
11-15 years	21	9	9
6-10 years	32	13	15
0-5 years	134	65	49

The importance of a firm’s age for R&D and other company-related measures is discussed by Ayygari et al. (2007), Hadlock and Pierce (2009), and Brown and Petersen (2011), among others.

We expected that the firm age of younger companies is likely to restrict access to leverage when financing innovations. Table 3.7 shows that oil and gas companies are on average twice as young (12 years) as utilities (24 years), with European energy industry firms an average of 24 years old. The majority of energy companies across subsectors of the industry are less than 5 years old, which indicates that stronger and more entrepreneurial companies tend to survive and remain in the business.

Private ownership of the company

With regard to the legal ownership status of the firm, we refer to a very early paper by Marshall (1907) and relatively recent studies by Shleifer (1998) and Ayygari et al. (2007), who found that privately owned companies have stronger incentives than state-owned enterprises to create profits. Privately owned companies therefore pay off financing expenditures by engaging in innovative technologies. At a more general level, Rajan and Zingales (1995) found that in G-7 countries, institutional differences can play a significant role in corporate leverage, and that it is necessary to measure the effects of country-specific conditions, such as the effects of taxes, bank-based versus market-based countries and ownership control.

We define the major owner of the company based on the entity that holds the largest stake in the company’s future. The OSIRIS database manual defines a company that is owned by another company as privately owned; when the company is owned by the state, governmental agencies, governmental departments or local authorities, it is considered to be owned by the state.

The argument in favour of private companies refers to the very basic assertion of Marshall (1907) that the government is generally a poor innovator because managers of state firms have relatively weak incentives to operate efficiently; more importantly, the managers of state firms lack the ownership rights and hence the motivation to lead businesses in a cost-effective manner. Recent studies have strengthened these two arguments. An extensive study by the World Bank (1995) found that in every industry ranging from grocery to air transportation, privately owned firms delivered the same and in many instances better quality services, at lower production costs. The main explanation for the success of private companies over state businesses lies in competition, which private companies face in the marketplace, whereas government firms are often large and monopolistic enterprises with no or few incentives to compete for their share of the market. In this regard, Shleifer (1998) and Ayyagari et al. (2007) support existing studies reporting that public managers have relatively weak incentives to make adequate returns on received investments because the motivation provided by ownership and profit is lacking.

The ownership literature describes a positive effect of private ownership on access to financing compared. Table 3.8 demonstrates that private ownership is associated with greater access to financing compared to state or any other form of ownership.

Table 3.8: Major ownership types, by countries, as per firm-level data

	Private	**State**	Emplo-yees	Self-owned	Public	Other type	Major owner-ship	Major owner type
Slovakia	88%	0%	0%	0%	13%	0%	88%	Private
Romania	72%	0%	0%	0%	28%	0%	72%	Private
Austria	71%	10%	0%	0%	16%	3%	71%	Private
Finland	59%	1%	0%	0%	41%	0%	59%	Private
Spain	50%	1%	0%	0%	15%	34%	50%	Private
Belgium	50%	0%	0%	0%	21%	29%	50%	Private
Germany	48%	7%	0%	0%	30%	15%	48%	Private
Hungary	46%	0%	0%	0%	20%	34%	46%	Private
Greece	45%	9%	0%	4%	31%	11%	45%	Private
France	45%	5%	0%	2%	16%	32%	45%	Private
Italy	44%	10%	0%	1%	20%	25%	44%	Private
Lithuania	41%	48%	0%	0%	11%	0%	48%	State
Portugal	38%	0%	0%	0%	12%	50%	50%	Other type
Denmark	32%	0%	4%	13%	32%	19%	32%	Private/Public
Latvia	32%	0%	0%	0%	2%	66%	66%	Other type
Ireland	28%	0%	0%	0%	41%	31%	41%	Public
Cz. Republic	27%	20%	0%	0%	13%	40%	40%	Other type
Poland	23%	0%	0%	0%	27%	50%	50%	Other type
UK	16%	0%	0%	0%	34%	50%	50%	Other type
Luxemburg	15%	13%	0%	0%	5%	67%	67%	Other type
Sweden	9%	0%	0%	0%	8%	83%	83%	Other type
Cyprus	7%	0%	0%	0%	93%	0%	93%	Public
Estonia	0%	0%	0%	0%	0%	100%	100%	Other type
Netherlands	0%	0%	0%	0%	0%	100%	100%	Other type
Average ownership type	37%	5%	0%	1%	22%	35%	37%	Private

This table lists the major owner of the company, according to the definitions outlined above. We concentrate on private status (owned by another company) and state status (owned by states, governmental agencies, governmental departments, or local authorities). The ownership segregation methodology follows the OSIRIS database's manual handbook. We provide other ownership types as a reference point only.

EU integration

Gros and Mortensen (2004) argued that integration into the EU market should facilitate R&D activity. They referred to the EU commitment, announced in March 2000 in Lisbon, where EU heads of state and government set the strategic goal to become the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion. These goals were confirmed at the Barcelona European Council, which added that investment in European R&D should be increased to 3% of GDP by 2010.

To our knowledge, no previous study has examined the impact of country integration on the European energy sector; therefore, we control for EU integration. We expect that older EU member countries have an advantage over companies in new-EU countries in attracting financing for R&D. That is, companies from the established EU countries may be able to use financial incentives more effectively; these companies are more familiar to investment providers and hence more trustworthy.

We control for the influence of integration on the energy sector companies since 2004 (new-EU countries), when nine countries joined the European Union, which then included 15 countries[4]. Those countries that joined the EU before 2004 are referred to as 'old EU' countries.

3.4. A model of financing and innovations

Our main empirical model is an unbalanced data panel (panel variable as company, time variable as year) on a yearly basis. We focused on the years with the most observations for R&D and leverage data, which cover the period from 1995–2007. Our estimation extends the existing firm-level studies in the energy industry (*see e.g.*, Balakrishnan and Fox, 1993; Mulder, 2008) by focusing on two major sectors: utilities and oil and gas producers.

The dependent variable is R&D, and financing is investigated as leverage and operating income, as discussed in Section 3.3. Given that there could be additional factors influencing leverage for innovation activities, we also analyse the effects of tax shields, liquidity, firm operating age (various age groups), firm ownership status (privately owned versus state-owned firms), and integration in the EU, as discussed in Section 3.3.3.

We follow the theoretical background procedure discussed in Chapter 2. We begin our estimation using the pooled Ordinary Least Squares (OLS) method. However, each firm has its own individual characteristics, which may or may not influence the regression results. The initial OLS regression may be biased because unobserved time-invariant country effects may be correlated with regressors; hence, we have to decide between the OLS-FE and the OLS-RE. Therefore we report various panel data specifications such as OLS-RE, OLS-FE, and OLS-FD and use the GMM estimator to control for the inclusion of the lagged dependent variable among the regressors. Further, following Arellano and Bond's GMM estimator, the lagged dependent variable is treated as endogenous, and the independent variables are treated as strictly exogenous (leverage, operating income, and a set of control measures). The GMM estimator used the second lag of the endogenous variable. We utilize only internal instruments and do not include additional external instruments. In each of the panel estimation specifications, we control for

[4] EU integration separates between old and new-EU countries. We define new EU member countries (9) as those that joined the EU on or after 2004. These are Cyprus (2004), the Czech Republic (2004), Estonia (2004), Hungary (2004), Lithuania (2004), Latvia (2004), Poland (2004), Romania (2007) and Slovakia (2004).

heteroscedasticity by means of White's standard errors. We also apply post-estimation tests for the statistical validity of the findings following the theoretical background presented in Chapter 2. Our empirical scrutiny focuses on the size, sign and significance of the estimated coefficients. We also produce results in terms of elasticities that allow us to measure the responsiveness of the dependent variable R&D to a change in the explanatory measure (refer to Chapter 2 for more explanation and Table 3.12 in the results section). The general equation is:

$$R\&D_{it} = \gamma_1 R\&D_{it-1} + \gamma_2 Leverage_{it} + \delta_1 Leverage_{it}^2 + \gamma_3 OperIncome_{it} + \gamma_4 Tax_{it} + \gamma_5 Liabilities_{it} + \alpha_i + u_{it} \quad \text{Eq. (3.1)}$$

where

$R\&D_{it}$ = R&D of the i-th firm in the t-th year,

α_i = represents a time-invariant unobserved intercept for each firm, commonly known as fixed effects,

u_{it}= is a unique firm's error term.

At first, to test the initial hypothesis that reduced leverage positively influences R&D, while higher leverage reduces R&D, we start with Eq. (3.1), which considers leverage, and then add the square of leverage. The inclusion of both leverage and its square term suggests that there is some potential threshold level after which an increased level of leverage may harm innovation activities (Tables 3.9 and 3.10). Eq. (3.1) is non-linear and parabolic; that is, the threshold of the leverage measure means calculating the inflexion point for the parabola[5]:

$$Leverage^* = -\frac{1}{2}\frac{\gamma_2}{\delta_1}$$

where

$Leverage^*$ = an inflexion point (threshold) for leverage

γ_2 and δ_1 = coefficients of the $Leverage_{it}$ and $Leverage_{it}^2$ variables from Eq. (3.1)

Further, we segregate companies with a total debt to total assets ratio of less than 0.5 from those with a ratio greater than 0.5. This leverage segmentation enables a

[5] Eq. (3.1) follows the parabola shape of a general equation ($y=x + x^2 + c$). The inflexion point is that where the slope of 'x' changes from positive to negative or from negative to positive. The parabola may become concave upwards or downwards depending on the signs of 'x' and 'x^2'. The relevant theoretical background is widely discussed in fundamental calculus and geometry books (e.g., Stewart, 2009 and Brannan et al., 2003).

distinction between the 'threshold' impact on leverage of companies that tend to balance sheet debt compared to those that rely more on external debt (Table 3.11 and additional detailed sub-sectoral tables in Appendix 3.A).

In order to test the second hypothesis that income may supplement financing for R&D, we introduce the operating income term. There is a possibility that in addition to leverage and operating income, there is a set of control variables that could result in diverse patterns of financing for R&D. For this reason, we introduce control measures that are commonly known to influence R&D activity, as described in Section 3.2. Also, inclusion of the lagged dependent on the right-hand-side of the equation serves as a control for the previous period's R&D activity.

In addition, we present estimates for Eq. (3.1) that control for operating age, employing 5-, 10- and 20-year age groups (Table 3.13 summarizes these age groups; the specifics are presented in Appendix 3.A). Further, we distinguished between estimates for privately owned and state-owned companies (Table 3.14 and additional tables in Appendix 3.A). Finally, we introduced controls for integration with the European Union. As stated above, countries that joined the EU after 2004 are called 'new EU' countries (Table 3.15; detailed subsector tables are presented in Appendix 3.A). In all control examinations, we distinguish the results for utilities, oil and gas producers and compare these with the overall energy sector estimates.

3.5. Results

This subsection provides panel data analysis to estimate the impact of financing ability on innovation activities (both measured by two proxies each) within the European energy industry and the two major subsectors—utilities and oil and gas production. Our results serve to document empirical regularities that are consistent with the relevant literature. In particular, we find that levels of debt within energy companies are differentially related to the engagement with innovation. Subsection 3.5.1 and Tables 3.9-3.12 present the summary findings, while the subsequent sub-sections suggest the importance of firm operating age (Table 3.13), ownership status (Table 3.14) and EU integration in innovation financing (Table 3.15). The tables presented in the main discussion are for all industries and energy industries, while Appendix 3.A provides additional detailed results tables covering two subsectors—utilities and oil and gas.

3.5.1. Summary of panel estimates of R&D

Firms with greater financial burden may find lenders reluctant to provide investment funds for capital-intensive technology developments with regards to uncertainty about generating enough future income to pay back the principal and cover interest payments. The findings of debt non-linearity for R&D activities are similar for the overall energy industry and both major sub-sectors (Tables 3.9 and 3.10)[6]. That is, the broad evidence on innovation financing is in line with the general studies on leverage and the R&D relationship—that the level of financial burden has a potential to adversely impact on innovation activity (e.g., Rajan and Zingales, 1995; Booth et. al., 2001; Cole, 2008, among others).

The control for the leverage non-linearity effect suggests that there is a threshold level of debt in relation to the extent to which companies engage in innovation. In other words, there is a particular point at which the debt level starts to adversely affect R&D activity. Notably, Eq. (3.1) is parabola shaped and the inflexion point can be calculated. Tables 3.9 and 3.10 indicate that the leverage threshold level for the energy industry is at about 30%, higher for utilities at around 40%, and lower for oil and gas producers at around 25%. Further, the threshold varies when considering various company age groups (Appendix Table 3.A.5) and the country's integration to the European Union (see Table 3.15). Thus, the low threshold level, which is even negative for companies located in countries that have recently joined the EU, suggests that energy companies are considered to be a risky business when investors are deciding whether or not to lend toward R&D engagement. Nonetheless, utilities inspire greater confidence than oil and gas firms.

We further distinguish between those companies with debt levels greater than 0.5 (a tendency for external debt financing) and those with levels lower than 0.5 (a tendency toward balance-sheet financing). Table 3.11 shows that an energy sector firm with a low

[6] The estimates with an alternative R&D proxy, such as 'R&D expenditure to sales ratio', yield weaker results (refer to Appendix 3.A.1). The literature notes that 'sales' may not be a valid proxy for 'total assets' due because the energy industry is capital intensive. Hence the ratio of R&D to total asset base is more appropriate.
Estimates of innovation financing based on an alternative leverage ratio indicate that having more liabilities distorts investments (refer to Appendix 3.A.2). Essentially, the liabilities ratio is viewed as a proxy for what is left for the shareholders in case of liquidation and may not be as representative as the main leverage considered, i.e., the total debt to total assets ratio (as discussed by Rajan and Zingales, 1995). Note that the descriptive statistics in Table 3.3 indicate that the liabilities ratio is much higher than the debt ratio, which explains why estimates of the 'liabilities' ratio demonstrate a negative impact of both the term and the square term on R&D (refer to Appendix 3.A). This finding of an alternative leverage measure is in line with the argument proposed by Mulder (2008), which states that a high level of leverage means the company takes an external focus, which is in turn associated with reduced R&D expenditure.

Table 3.9: A summary of panel estimates with control variables for R&D in energy sector firms, 1995–2007

	Pooled OLS (without controlling for year) 1	Pooled OLS 2	OLS RE 3	OLS FE 4	First Difference (robust clustered) 5	GMM (inclusion of the lagged dependent) 6
Total debt to total assets	**0.122*** (0.0664)	0.0948 (0.0650)	**0.0948*** (0.0557)	**0.123**** (0.0585)	0.113 (0.104)	**0.120***** (0.0360)
Total debt to total assets, squared	**-0.183**** (0.0892)	**-0.175**** (0.0881)	**-0.175**** (0.0862)	**-0.200**** (0.0906)	-0.214 (0.139)	**-0.209***** (0.0616)
Operating income	-0.0351 (0.0375)	-0.0453 (0.0380)	**-0.0453*** (0.0234)	-0.0118 (0.0242)	-0.0108 (0.0304)	**-0.0409**** (0.0194)
Tax to total assets	0.0426 (0.118)	0.103 (0.117)	0.103 (0.124)	0.0515 (0.128)	-0.0870 (0.0915)	0.0344 (0.0948)
Liquidity	-0.00310 (0.00223)	-0.00326 (0.00224)	**-0.00326***** (0.000742)	**-0.00406***** (0.000757)	**0.00275*** (0.00153)	**0.00190***** (0.000543)
Lag of R&D dependent						**0.721***** (0.0298)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.0853***** (0.0177)	**-8.579***** (2.080)	**-8.579***** (2.229)	**-7.815***** (2.227)	0.000491 (0.00356)	**30.53**** (12.71)
Threshold debt level	0.33	0.27	0.27	0.31	0.26	0.29
Observations	1,191	1,191	1,191	1,191	976	1,136
Number of companies	193	193	193	193	170	188
Joint test	0.0687	0.0323	0.0000	0.0000	0.1273	0.0000
Years test		0.0000	0.0000	0.0002		0.0295
Hausman test				0.0000		
Weak-instrument test						0.0000

Note: White's standard errors were applied to control for heteroscedasticity.

This table demonstrates the main focus: the effects of corporate leverage (H1) and operating income (H2) on innovation, with controls for tax shields and liquidity. The regression results are based on various panel data specifications, with alternative R&D and leverage proxies estimated as in Appendix 3.A. The regression methodology is discussed in Chapter 2. The main dependent R&D proxy is defined as the ratio of 'R&D expenditure to total assets'. Definitions of the measures used are presented in Sections 3.3.1-3.3.3. The joint test, years test and weak-instrument test are presented as 'Prob>F'. The legends (*) to the right of the coefficients denote the significance levels (* p<0.1; ** p<0.05; *** p<0.01).

ratio has less total debt in comparison to its asset base and hence is less financially stressful, which allows for engagement in R&D activities (for the details of both subsectors refer to Appendix 3.A.: Tables 3.A.3 and 3.A.4). The results also indicate that operating income may be used as an additional financing supplement for funding innovations, but the evidence for this is weak and rather mixed.

We also find that the previous year's R&D activity positively impacts the current level of innovation (refer to the last column in each of the tables). The preceding engagement with R&D may indicate the company's ability to find the required sources of investment and thus provides an additional level of credibility while securing the funds.

Table 3.10: Summary of panel estimates of R&D including control variables: Utilities and oil and gas sectors, 1995–2007

	Pooled OLS (without years control) 1	Pooled OLS 2	OLS RE 3	OLS FE 4	First Difference (robust clustered) 5	GMM (inclusion of lagged dependent) 6
A. Utilities						
Total debt to total assets	**0.201***** (0.0606)	**0.156***** (0.0565)	**0.156***** (0.0540)	**0.136**** (0.0565)	0.00136 (0.0747)	**0.116**** (0.0466)
Total debt to total assets, squared	**-0.225***** (0.0826)	**-0.189**** (0.0785)	**-0.189**** (0.0802)	**-0.167**** (0.0829)	-0.0525 (0.0823)	**-0.233***** (0.0800)
Operating income	-0.0259 (0.0358)	-0.0383 (0.0349)	-0.0383 (0.0436)	-0.0226 (0.0447)	**-0.0270*** (0.0161)	-0.0353 (0.0403)
Tax to total assets	**0.397**** (0.155)	**0.263*** (0.145)	0.263 (0.181)	0.290 (0.185)	**0.203*** (0.112)	0.0968 (0.181)
Liquidity	0.000284 (0.00570)	0.00127 (0.00559)	0.00127 (0.00293)	0.00102 (0.00304)	-0.000780 (0.0111)	**0.00678**** (0.00277)
Lag of R&D dependent						**0.769***** (0.0354)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.0499***** (0.0137)	**-7.817***** (2.232)	**-7.817***** (2.313)	**-7.812***** (2.333)	**0.00473**** (0.00208)	19.55 (15.11)
Threshold debt level	0.45	0.41	0.41	0.41	0.01	0.25
Observations	649	649	649	649	548	630
Number of companies	94	94	94	94	87	93
Joint test	0.0005	0.0161	0.0168	0.0753	0.0844	0.0000
Years test		0.0000	0.0001	0.0001		0.0657
Hausman test				0.9565		
Weak-instrument test						0.0000
B. Oil and gas producers						
Total debt to total assets	**0.322*** (0.182)	**0.316*** (0.182)	**0.316*** (0.164)	**0.518***** (0.177)	**0.441*** (0.259)	0.0723 (0.0908)
Total debt to total assets, squared	**-0.689**** (0.290)	**-0.708**** (0.291)	**-0.708**** (0.287)	**-1.028***** (0.315)	**-0.958**** (0.395)	-0.123 (0.159)
Operating income	-0.0108 (0.0626)	-0.0139 (0.0603)	-0.0139 (0.0447)	**0.0432*** (0.0466)	0.0217 (0.0469)	**0.00284*** (0.0357)
Tax to total assets	0.0894 (0.186)	0.192 (0.190)	0.192 (0.248)	0.0525 (0.256)	-0.0618 (0.129)	0.202 (0.161)
Liquidity	**-0.00385*** (0.00222)	**-0.00380*** (0.00228)	**-0.00380***** (0.00108)	**-0.00451***** (0.00108)	0.00244 (0.00150)	0.00105 (0.000719)
Lag of R&D dependent						**0.765***** (0.0437)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.129***** (0.0377)	-6.503 (4.613)	-6.503 (5.635)	-3.930 (5.597)	-0.00899 (0.00990)	**56.68*** (31.30)
Threshold debt level	0.23	0.22	0.22	0.25	0.05	0.29
Observations	348	348	348	348	270	323
Number of companies	67	67	67	67	54	63
Joint test	0.0224	0.0170	0.0013	0.0001	0.0000	0.0000
Years test		0.3361	0.6623	0.6161		0.6199
Hausman test				0.0041		
Weak-instrument test						0.0000

Note: White's standard errors were applied to control for heteroscedasticity.

This table continues Table 3.9 but concentrates on the two energy sub-sectors. As in Table 3.9, the regression results are based on various specifications for panel data estimation. The regression methodology is discussed in Chapter 2; the threshold approach in discussed in Methodology Section 3.4. The main dependent R&D proxy is defined as the ratio of 'R&D expenditure to total assets'. Definitions of the measures are presented in Sections 3.3.1-3.3.3. The joint test, years test and weak-instrument tests are presented as 'Prob>F'. The legends (*) to the right of the coefficients denote the significance levels (* $p<0.1$; ** $p<0.05$; *** $p<0.01$).

Table 3.11: Panel estimates for R&D: Energy sector with leverage levels, 1995–2007

	Pooled OLS (without years control) 1	Pooled OLS 2	OLS RE 3	OLS FE 4	First Difference (robust clustered) 5	GMM (inclusion of lagged dependent) 6
A. Tendency to finance with balance sheet (ratio <0.5)						
Total debt to total assets	**0.0575****	0.0349	0.0349	**0.0436***	-0.0287	0.00821
	(0.0253)	(0.0243)	(0.0218)	(0.0231)	(0.0417)	(0.0131)
Operating income	0.0184	0.00355	0.00355	0.0412	0.0183	0.0187
	(0.0383)	(0.0391)	(0.0292)	(0.0309)	(0.0365)	(0.0252)
Tax to total assets	0.103	0.182	0.182	0.148	-0.120	0.0615
	(0.152)	(0.149)	(0.143)	(0.149)	(0.121)	(0.103)
Liquidity	0.00199	0.00194	**0.00194****	**0.00197****	0.00151	**0.00148*****
	(0.00180)	(0.00181)	(0.000863)	(0.000938)	(0.00150)	(0.000546)
Lag of R&D dependent						**0.704*****
						(0.0350)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.0668*****	**-8.829*****	**-8.829*****	**-8.294*****	-0.00317	**36.48*****
	(0.0140)	(2.146)	(2.083)	(2.097)	(0.00491)	(13.47)
Observations	1,044	1,044	1,044	1,044	862	1,001
Number of companies	175	175	175	175	157	174
Joint test	0.0970	0.1483	0.0600	0.0471	0.3379	0.0000
Years test		0.0000	0.0000	0.0000		0.0218
Hausman test				0.0213		
Weak-instrument test						0.0000
B. Tendency to finance with external debt (ratio >=0.5)						
Total debt to total assets	**-0.128****	**-0.142****	**-0.142****	-0.0584	-0.0400	-0.0421
	(0.0498)	(0.0557)	(0.0562)	(0.0633)	(0.0356)	(0.0342)
Operating income	-0.00952	-0.0307	-0.0307	-0.00267	**-0.0478*****	**-0.0835****
	(0.0265)	(0.0278)	(0.0383)	(0.0388)	(0.0118)	(0.0326)
Tax to total assets	**0.600*****	**0.606*****	**0.606***	0.579	-0.261	0.199
	(0.225)	(0.226)	(0.325)	(0.385)	(0.232)	(0.185)
Liquidity	-0.00468	-0.00489	**-0.00489*****	**-0.00522*****	**0.0119*****	**0.00677*****
	(0.00320)	(0.00302)	(0.00187)	(0.00188)	(0.00171)	(0.00214)
Lag of R&D dependent						**0.676*****
						(0.0503)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.200*****	**-7.778*****	-7.778	-5.661	0.0146	-13.86
	(0.0421)	(2.780)	(9.874)	(9.623)	(0.0169)	(35.24)
Observations	147	147	147	147	114	135
Number of companies	66	66	66	66	52	62
Joint test	0.0296	0.0092	0.0071	0.0579	0.0000	0.0000
Years test		0.1380	0.8910	0.7823		0.1098
Hausman test				0.0000		
Weak-instrument test						0.0000

Note: White's standard errors were applied to control for heteroscedasticity.

This table advances on Tables 3.9 and 3.10 by segmentation of the leverage between those companies with tendency of debt financing through the balance sheets and those with external debts. As in Tables 3.9 and 3.10 the regression results are based on various specifications for data estimation. The regression methodology was performed as discussed in Chapter 2. The main dependent R&D proxy is defined as the ratio of 'R&D expenditure to total assets'. Definitions of the measures are presented in Sections 3.3.1-3.3.3. The joint test, years test and weak-instrument test are presented as 'Prob>F'. The legends (*) to the right of the coefficients denote the significance levels (* p<0.1; ** p<0.05; *** p<0.01).

Table 3.12 shows the degree to which R&D is affected by a change in the explanatory variables measured by elasticity. Elasticity follows the same pattern for utilities and oil and gas producers. That is, R&D is highly inelastic to the lower debt levels, and also operating income, taxes, liquidity and last period R&D activity. The elasticity of innovations to the greater leverage level indicates that these are of the importance towards R&D engagement. To this extent, a 1% change in the greater leverage levels will lead to a negative elastic change in R&D (for oil and gas between -1.59% to -2.37% and for utilities between -1.25% and -1.68%). That is the greater change in leverage ($Leverage_{it}^2$) will deter companies from R&D due to the higher financing burden associated with larger borrowing.

Table 3.12: Panel estimates R&D: as elasticity, 1995–2007

	Pooled OLS (without years control) 1	Pooled OLS 2	OLS RE 3	OLS FE 4	First Difference (robust clustered) 5	GMM (inclusion of lagged dependent) 6
A. Energy sector						
Total debt to total assets	0.29	0.22	0.22	0.29	0.26	0.28
Total debt to total assets, squared	-0.86	-0.82	-0.82	-0.94	-1.00	-0.98
Operating income	-0.07	-0.10	-0.10	-0.03	-0.02	-0.09
Tax to total assets	0.01	0.02	0.02	0.01	-0.01	0.01
Liquidity	-0.14	-0.14	-0.14	-0.18	0.12	0.08
Lag of R&D dependent						0.72
B. Utilities						
Total debt to total assets	0.75	0.58	0.58	0.51	0.01	0.43
Total debt to total assets, squared	-1.68	-1.41	-1.41	-1.25	-0.39	-1.74
Operating income	-0.06	-0.08	-0.08	-0.05	-0.06	-0.08
Tax to total assets	0.09	0.06	0.06	0.06	0.04	0.02
Liquidity	0.02	0.07	0.07	0.06	-0.04	0.38
Lag of R&D dependent						0.77
C. Oil and gas producers						
Total debt to total assets	0.37	0.36	0.36	0.60	0.01	0.08
Total debt to total assets, squared	-1.59	-1.64	-1.64	-2.37	-0.13	-0.28
Operating income	-0.01	-0.01	-0.01	0.03	0.00	0.00
Tax to total assets	0.01	0.02	0.02	0.01	0.03	0.02
Liquidity	-0.13	-0.13	-0.13	-0.15	-0.03	0.04
Lag of R&D dependent						0.77

This table continues on Tables 3.9 and 3.10 by presenting the elasticity for Energy sector and two sub-sectors. The elasticity defines the per cent change in the dependent for a 1% change in the explanatory. The mathematical presentation is 'Elasticity = Estimated explanatory coefficient * (Mean explanatory measure/Mean dependent measure)'. Chapter 2 provides detailed explanation on elasticity calculation. For instance, in GMM application for the Energy sector, the 'total debt to total assets' elasticity of 0.28 means that on average for a 1% increase in debt, R&D would increase by 0.28% (Elasticity = 0.120*(0.2411/0.1030) = 0.28, where the explanatory coefficient is from Table 3.9, and the mean measures are from Table 3.2 and Table 3.3.)

It has to be cautioned that our results do not provide an effect of the variety of debt specifications arising directly from collateral availability, company valuation or specific tax shields and regulations imposed by the financial institutions. Instead we concentrate on the common debt proxies that are viewed as an essential of doing business, with control for both current and long-term liabilities (total debt to total assets, and total liabilities to total assets ratios). Nevertheless, the selection of the debt proxies opens a question as to whether the selected measures do appropriately capture the relevant financial conditions within the energy sector. Our logic in selecting the 'general' debt ratio is rather driven by the aim of the research—that is to uncover the relation between financing and R&D, while further research may use it as a foundation to concentrate on specific conditions and relationships within energy innovations area.

The implemented empirical approaches to panel data estimation including controlling for heteroscedasticity and the reported post-estimation tests suggest that the given results are valid. That is, from the OLS perspective, the OLS-FE and GMM are the most appropriate panel data estimation methods, as discussed in the theoretical background Chapter 2. The reported statistics for the joint significance of the included explanatory variables suggests that these are jointly significant and hence should be included. The years test indicates that control for the specific time occurrences is important (i.e. inclusion of year dummies). Also the Hausman test indicates that fixed effects should be preferred in the OLS specification allowing control for the correlation between the individual and/or time effects and the independent variables. In regards to the dynamic panel specification (GMM), the F-statistics is used as a test for 'weak' instruments (Baum et. al., 2007). We do not include additional external instruments and therefore the Sargan test is not reported. The external instruments are not included as there are too many measures to choose from and this is rather left for the future analysis along with the concentration on individual countries in order to form more detailed understanding of the financing innovations.

In a summary, the above empirical results of debt and operating income suggest that the energy industry and in particular major subsectors—utilities and oil and gas companies—may be driven by various other factors too. For this reason we introduce an examination of the financing relation to R&D through the selected control groups: time in operation (firm age), ownership status (state versus privately owned) and the EU integration effect on the innovation activities. The group controls may also explain why at a general results level the additional explanatory variables (tax to assets, and liquidity ratios) are not significant in the current relation to R&D.

3.5.2. Panel estimates of R&D: control for firm age, 1995–2007

Estimates of the effect of operational age on financing innovations suggest that age is an important characteristic. The age control indicates that the more mature companies tend to use significantly more debt than younger rival companies; however as we show the age segmentation allows us to identify some important occurrences within the energy industry (refer to Table 3.13 and for the detailed age groups refer to Appendix 3.A.5). The difference in financing between various age level firms is most likely reflected by the aptitude to operate with its presence in the market (as a capacity to do the business) for which the new companies are lacking. In other words, the company's long-term presence in the business may indicate the ability to borrow and repay on the received liabilities and hence possess higher opportunities to convince lenders to provide required funds for R&D. This supports general literature findings on company's age importance (see *e.g.*, Ayygari et al., 2007, Hadlock and Pierce, 2009, Brown and Petersen, 2011).

The age control results suggest that company may not be able to borrow continuously when it is needed. That is using experiments with operational age subgroups we identified the borrowing availability 'windows' as of 5, 10 and 20 years. That is once companies were able to access financing for R&D, these do not engage in the capital intensive investments for the specific period of time; and the more mature a company becomes the more borrowing 'window' widens. That is firms, which were able to borrow in the past, have higher borrowing capacities and access to the funds relative to R&D activities. Thus, rather than indicating the age effect, there is a possibility that established companies are naturally able to borrow when needed, as these firms possess the borrowing record which may be used as an assurance to lenders for receiving future repayments from R&D generated incomes.

Table 3.13: Panel estimates of R&D: Energy sector with additional control for firm age group (summary estimates), 1995–2007

	Pooled OLS (without years control)	Pooled OLS	OLS RE	OLS FE	First Difference (robust clustered)	GMM (inclusion of lagged dependent)
	1	2	3	4	5	6
1. Firm age (<5 years)						
Total debt to total assets	0.0078	-0.00269	-0.00269	-0.01	-0.0784	0.0093
	(0.0680)	(0.0699)	(0.0992)	(0.1060)	(0.0858)	(0.0827)
Total debt to total assets, squared	-0.0408	-0.057	-0.057	-0.0413	0.0686	-0.035
	(0.0760)	(0.0820)	(0.1340)	(0.1430)	(0.0902)	(0.1250)
Operating income	-0.115	-0.0842	-0.0842	0.194	0.0849	0.0734
	(0.2490)	(0.2600)	(0.1810)	(0.1790)	(0.0812)	(0.0724)
2. Firm age (6-10 years)						
Total debt to total assets	-0.115	-0.0842	-0.0842	0.194	0.0849	0.0734
	(0.2490)	(0.2600)	(0.1810)	(0.1790)	(0.0812)	(0.0724)
Total debt to total assets, squared	0.169	0.141	0.141	-0.166	-0.0452	-0.077
	(0.3640)	(0.3780)	(0.2840)	(0.2740)	(0.1090)	(0.1180)
Operating income	-0.0574	-0.0777	-0.0777	0.00857	0.00172	-0.0103
	(0.0545)	(0.0607)	(0.0646)	(0.0592)	(0.0160)	(0.0306)
3. Firm age (11-15 years)						
Total debt to total assets	**-0.253***	**-0.250***	**-0.250****	**-0.294****	**-0.427****	-0.0985
	(0.1440)	(0.1440)	(0.1110)	(0.1150)	(0.2000)	(0.0772)
Total debt to total assets, squared	**0.454***	**0.447***	**0.447****	**0.417****	**0.742****	**0.256***
	(0.2550)	(0.2550)	(0.1920)	(0.1920)	(0.3520)	(0.1450)
Operating income	-0.101	-0.0991	-0.0991	0.0062	-0.139	**-0.198*****
	(0.0723)	(0.0816)	(0.0632)	(0.0626)	(0.0875)	(0.0554)
4. Firm age (16-25 years)						
Total debt to total assets	-0.272	-0.26	-0.26	-0.164	0.137	0.144
	(0.1810)	(0.2270)	(0.2240)	(0.2780)	(0.2020)	(0.1170)
Total debt to total assets, squared	0.298	0.28	0.28	0.185	-0.285	-0.291
	(0.2340)	(0.3060)	(0.3550)	(0.4210)	(0.2630)	(0.1880)
Operating income	-0.105	-0.0899	**-0.0899***	-0.0467	-0.0728	**-0.0865****
	(0.0878)	(0.0984)	(0.0539)	(0.0552)	(0.0535)	(0.0339)
5. Firm age (26-45 years)						
Total debt to total assets	**0.669*****	**0.631****	**0.631****	0.213	**0.686*****	**0.402*****
	(0.1590)	(0.2930)	(0.3160)	(0.2040)	(0.2200)	(0.1350)
Total debt to total assets, squared	**-0.893*****	-0.751	-0.751	-0.233	**-1.086*****	**-0.677*****
	(0.2740)	(0.4670)	(0.5070)	(0.3170)	(0.3580)	(0.2120)
Operating income	0.177	-0.368	**-0.368***	**0.469*****	**0.431*****	**0.471*****
	(0.1840)	(0.4420)	(0.1890)	(0.1240)	(0.0880)	(0.1130)
6. Firm age (46-65 years)						
Total debt to total assets	0.0473	0.218	0.218	0.0421	-0.0128	0.155
	(0.1190)	(0.1720)	(0.1880)	(0.1740)	(0.0849)	(0.0976)
Total debt to total assets, squared	0.0957	-0.124	-0.124	0.157	0.0912	-0.158
	(0.1810)	(0.2700)	(0.2690)	(0.2330)	(0.1230)	(0.1590)
Operating income	**-0.276*****	-0.111	-0.111	**-0.316****	-0.0219	0.107
	(0.1010)	(0.1520)	(0.1490)	(0.1370)	(0.0434)	(0.0850)
7. Firm age (66-85 years)						
Total debt to total assets	**0.601****	**0.502****	**0.502****	0.414	0.573	**0.264****
	(0.2600)	(0.2220)	(0.2440)	(0.3610)	(0.4280)	(0.1250)
Total debt to total assets, squared	**-1.118****	-0.883	**-0.883***	-1.045	**-1.494****	**-0.703****
	(0.5460)	(0.5700)	(0.5360)	(0.6550)	(0.7310)	(0.2720)
Operating income	-0.356	**-0.847****	**-0.847*****	-0.393	0.137	-0.000154
	(0.3400)	(0.3770)	(0.2830)	(0.3280)	(0.1440)	(0.1510)
8. Firm age (86-105 years)						
Total debt to total assets	-0.253	**-0.445***	**-0.445*****	**-0.467****	-0.0373	0.037
	(0.2690)	(0.2490)	(0.1690)	(0.1800)	(0.2580)	(0.1160)
Total debt to total assets, squared	-0.0801	0.0473	0.0473	0.0533	-0.195	-0.217
	(0.4750)	(0.4310)	(0.3060)	(0.3260)	(0.3130)	(0.2100)
Operating income	0.12	0.112	0.112	0.129	0.0411	-0.0943
	(0.1790)	(0.1760)	(0.1610)	(0.1760)	(0.1190)	(0.0944)
9. Firm age (106+ years)						
Total debt to total assets	**0.953****	**1.159*****	**1.159*****	**1.287*****	0.766	**0.844*****
	(0.4160)	(0.2720)	(0.2150)	(0.4650)	(0.5570)	(0.2100)
Total debt to total assets, squared	**-1.702****	**-2.131*****	**-2.131*****	**-2.141*****	**-1.703****	**-1.649*****
	(0.7280)	(0.4760)	(0.3820)	(0.7400)	(0.8130)	(0.3780)
Operating income	**-0.858****	**-1.877*****	**-1.877*****	-0.336	-0.232	**-0.963*****
	(0.3890)	(0.2850)	(0.2520)	(0.3980)	(0.5360)	(0.2920)

Note: White's standard errors were applied to control for heteroscedasticity.

This table advances on Tables 3.9-3.12. As before, the regression results are based on various panel data specifications with detailed age groups as explained in Appendix 3.A. The regression methodology is discussed in Chapter 2. The main dependent R&D proxy is defined as the ratio of 'R&D expenditure to total assets'. The dependent and explanatory variables definitions are presented in Sections 3.3.1-3.3.3. The joint test, years test and weak-instrument test are presented as 'Prob>F'. The legends (*) to the right of the coefficients denote the significance levels (* p<0.1; ** p<0.05; *** p<0.01).

3.5.3. Panel estimates of R&D: control for ownership status, 1995–2007

The ownership analysis of the energy industry suggests that debt is an important variable for R&D activities for both state-owned and privately owned energy firms (Table 3.14 and for the two subsectors in the Appendix Table 3.A.6 and Table 3.A.7). Recalling on definitions, we refer to state ownership if the government owns more than 51% of the firm; otherwise we denote as privately owned (those owned by other companies as a major owner). If anything, debt is more important for gas companies across the two ownership types (see Appendix Table 3.A.7). However, comparing results from Table 3.A.7 with Table 3.A.6, the results indicate that state controlled companies, whether these are utilities or oil and gas, are less affected by the burden of greater borrowing compared to privately owned firms.

Further, the estimates demonstrate that the energy sector liquidity (liquidity ratio) is most neglected in the oil and gas subsector. Moreover, the state-owned oil and gas companies require even greater liquidity improvements compared to the privately-owned firms.

Ownership control implementation yields similar results as if no ownership is applied, yet provides an insight of how ownership segmentation may to a greater or lesser effect reflect on the R&D activities among the utilities and oil and gas companies. That is, the R&D is greater impacted by financing in oil and gas firms in both ownership type companies, while the negative effect of low liquidity on R&D is more concerned within the state companies. The findings are in line with Shleifer (1998) and Ayygari et al. (2007), who found that private firms are more likely to attract financing as these firms have higher incentives to engage in R&D in order to compete with other firms in the market.

Table 3.14: Panel estimates of R&D: Energy sector with additional control for ownership type, 1995–2007

	Pooled OLS (without years control) 1	Pooled OLS 2	OLS RE 3	OLS FE 4	First Difference (robust clustered) 5	GMM (inclusion of lagged dependent) 6
A. 'Private' ownership						
Total debt to total assets	0.0940 (0.0725)	0.0719 (0.0714)	0.0719 (0.0606)	**0.104*** (0.0635)	0.119 (0.112)	**0.0992**** (0.0386)
Total debt to total assets, squared	**-0.162*** (0.0964)	**-0.160*** (0.0964)	**-0.160*** (0.0931)	**-0.185*** (0.0976)	-0.227 (0.149)	**-0.181***** (0.0658)
Operating income	-0.0330 (0.0374)	-0.0407 (0.0377)	**-0.0407*** (0.0244)	-0.00838 (0.0252)	-0.00951 (0.0307)	**-0.0442**** (0.0199)
Tax to total assets	0.0455 (0.125)	0.0910 (0.124)	0.0910 (0.134)	0.0242 (0.137)	-0.105 (0.0972)	0.0729 (0.101)
Liquidity	-0.00325 (0.00223)	-0.00340 (0.00225)	**-0.00340***** (0.000772)	**-0.00414***** (0.000786)	**0.00272*** (0.00154)	**0.00158***** (0.000554)
Lag of R&D dependent						**0.696***** (0.0304)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.0966***** (0.0198)	**-7.973***** (2.374)	**-7.973***** (2.500)	**-7.090***** (2.499)	-0.000638 (0.00426)	**40.89***** (14.01)
Threshold debt level	0.29	0.22	0.22	0.28	0.26	0.27
Observations	1,034	1,034	1,034	1,034	843	980
Number of companies	170	170	170	170	147	165
Joint test	0.1386	0.0678	0.0000	0.0000	0.1120	0.0000
Years test		0.0001	0.0025	0.0079		0.0115
Hausman test				0.0174		
Weak-instrument test						0.0000
B. 'State' ownership						
Total debt to total assets	**0.366***** (0.109)	**0.271***** (0.104)	**0.271**** (0.129)	**0.189*** (0.150)	0.0713 (0.243)	**0.209**** (0.0929)
Total debt to total assets, squared	**-0.422**** (0.173)	-0.275 (0.172)	-0.275 (0.225)	-0.126 (0.251)	-0.0546 (0.304)	**-0.322*** (0.164)
Operating income	-0.0363 (0.180)	0.00916 (0.160)	0.00916 (0.199)	-0.0273 (0.206)	-0.134 (0.143)	-0.119 (0.176)
Tax to total assets	-0.0109 (0.330)	**0.482*** (0.255)	0.482 (0.435)	0.718 (0.449)	-0.0870 (0.260)	-0.160 (0.380)
Liquidity	0.00454 (0.00642)	0.00134 (0.00453)	0.00134 (0.00730)	0.00323 (0.00917)	0.0210 (0.0132)	0.00672 (0.00500)
Lag of R&D dependent						**0.746***** (0.0726)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	-0.00375 (0.0174)	**-12.88***** (2.883)	**-12.88***** (4.054)	**-14.15***** (4.134)	0.00628 (0.00392)	-35.29 (26.45)
Threshold debt level	0.43	0.49	0.49	0.75	0.65	0.32
Observations	157	157	157	157	133	156
Number of companies	23	23	23	23	23	23
Joint test	0.0111	0.0028	0.0250	0.0328	0.4288	0.0000
Years test		0.0000	0.0002	0.0004		0.0517
Hausman test				0.0932		
Weak-instrument test						0.0001

Note: White's standard errors were applied to control for heteroscedasticity.

This table summarises the R&D estimates between private and stated owned companies. As before the regression results are based on various specifications for data estimation (refer to Chapter 2). The dependent R&D proxy is defined as the ratio of 'R&D expenditure to total assets'. The variables definitions are presented in Sections 3.3.1-3.3.3. The joint test, years test and weak-instrument test are presented as 'Prob>F'. The legends (*) to the right of the coefficients denote the significance levels (* p<0.1; ** p<0.05; *** p<0.01).

3.5.4. Panel estimates of R&D: control for EU integration, 1995–2007

In our prior estimation, we considered the effect of control measures on financing innovation including the firm's operational age as a proxy for the firm's economic credibility and the greater attraction of private ownership for investment in R&D activities. In this subsection, we proceed with regressions to examine the importance of a firm's integration in the EU area to its ability to attract investments in R&D (refer to Tables 3.15 and 3.A.9 and Appendix 3.A.8 for sub-sectoral estimates). We distinguished between old-EU (joined the EU before 2004) and new-EU (joined the EU on or after 2004) member countries. This may highlight the importance of introducing incentives to invest in R&D among companies in new EU states in order to compete with established firms.

The results are different for old and new-EU countries. We find that both leverage and operating income hold their significance for established companies in old-EU countries. Whereas energy companies in newly joined EU countries are finding issues with access to external financing and rely more on the internally generated operating income. Even tax shields are not able to provide financing incentives in the new-EU countries.

The control for EU integration provides an important opportunity to discuss what could be done to attract financing for innovation. The introduction of additional incentives and the ease of access to a common European energy market might stimulate investment. Furthermore, EU membership and tax incentives may only encourage investment over the long term. This finding is in line with findings reported by Gros and Mortensen (2004), who argued that new-EU countries are required to facilitate sustainable economic growth in the EU and therefore invest heavily in R&D.

Table 3.15: Panel estimates of R&D: The energy sector with additional controls for EU integration, 1995–2007

	Pooled OLS (without years control)	Pooled OLS	OLS RE	OLS FE	First Difference (robust clustered)	GMM (inclusion of lagged dependent)
	1	2	3	4	5	6
A. Old-EU countries (joined prior to 2004)						
Total debt to total assets	0.123	0.0943	0.0943	**0.189****	0.0319	0.000822
	(0.0932)	(0.0873)	(0.0701)	(0.0745)	(0.0825)	(0.0445)
Total debt to total assets, squared	-0.111	-0.132	-0.132	**-0.258****	-0.0663	-0.0154
	(0.148)	(0.140)	(0.115)	(0.119)	(0.122)	(0.0803)
Operating income	-0.0253	-0.0268	-0.0268	0.0302	-0.0211	**-0.0363***
	(0.0597)	(0.0578)	(0.0260)	(0.0268)	(0.0315)	(0.0205)
Tax to total assets	0.258	**0.283***	**0.283***	**0.279***	0.0777	-0.106
	(0.167)	(0.156)	(0.154)	(0.153)	(0.0804)	(0.131)
Liquidity	0.00200	0.00160	0.00160	-0.000333	-0.00296	**0.00246***
	(0.00397)	(0.00377)	(0.00195)	(0.00207)	(0.00518)	(0.00143)
Lag of R&D dependent						**1.114*****
						(0.0479)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.0519*****	0	0	**-14.59*****	**0.00810*****	**21.13***
	(0.0173)	(0)	(0)	(2.622)	(0.00228)	(12.45)
Threshold debt level	0.55	0.36	0.36	0.37	0.24	0.03
Observations	603	603	603	603	475	572
Number of companies	123	123	123	123	108	119
Joint test	0.0513	0.1884	0.1270	0.0570	0.7565	0.0000
Years test		0.0000	0.0000	0.0000		0.0255
Hausman test				0.0000		
Weak-instrument test						0.0001
A. New-EU countries (joined post 2004)						
Total debt to total assets	-0.0106	-0.00960	-0.00960	-0.0430	0.128	**0.242*****
	(0.105)	(0.104)	(0.0913)	(0.106)	(0.157)	(0.0568)
Total debt to total assets, squared	-0.0679	-0.0695	-0.0695	-0.0193	-0.249	**-0.386*****
	(0.126)	(0.125)	(0.129)	(0.146)	(0.207)	(0.0933)
Operating income	-0.0515	-0.0552	-0.0552	0.00850	0.00885	-0.0343
	(0.0455)	(0.0452)	(0.0367)	(0.0391)	(0.0506)	(0.0354)
Tax to total assets	0.0799	0.0951	0.0951	-0.0185	-0.176	0.0916
	(0.157)	(0.155)	(0.178)	(0.189)	(0.127)	(0.137)
Liquidity	-0.00213	-0.00217	**-0.00217****	**-0.00300*****	**0.00303***	**0.00215*****
	(0.00291)	(0.00292)	(0.000846)	(0.000868)	(0.00169)	(0.000665)
Lag of R&D dependent						**0.602*****
						(0.0440)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.116*****	0	0	2.422	-0.00359	**27.58***
	(0.0258)	(0)	(0)	(5.834)	(0.00408)	(14.80)
Threshold debt level	-0.08	-0.07	-0.07	-1.11	0.26	0.31
Observations	588	588	588	588	501	564
Number of companies	185	185	185	185	162	179
Joint test	0.5085	0.4523	0.0283	0.0194	0.0748	0.0000
Years test		0.0001	0.0000	0.0600		0.0344
Hausman test				0.0008		
Weak-instrument test						0.0001

Note: White's standard errors were applied to control for heteroscedasticity.

This table is similar to Table 3.14 but concentrates on financing for R&D upon EU integration. As before, the regression results are based on various specifications for panel data estimation. The regression methodology is discussed in Chapter 2. The main dependent R&D proxy is defined as the ratio of 'R&D expenditure to total assets'. The dependent and explanatory variable definitions are presented in Sections 3.3.1.-3.3.3. The joint test, years test and weak-instrument tests are presented as 'Prob>F'. The legends (*) to the right of the coefficients denote the significance levels (* p<0.1; ** p<0.05; *** p<0.01).

3.6. Concluding comments

This chapter primarily investigates the effects of leverage on financing R&D in the European energy industry for the period from 1995–2007. This study period was selected based on the availability of company data. Due to the incomplete nature of the data set, the results presented should be treated as rather exploratory.

We indicate that in order to understand innovation financing, factors such as tax shields, liquidity, firm age, differences in ownership type and EU integration should be considered. Unlike many existing studies, our analysis has accounted for the increasing importance of innovation in the energy sector. These efforts at innovation strive to meet the growing demand for energy amid concerns about security and stability as well as the demand for new technologies for more efficient energy use. We were able not only to consider the energy industry, but also to compare the major sectors—utilities and oil and gas production—with respect to their obvious contributions to the European economy.

There is consistent evidence that controlling for leverage and operating income availability has met with limited success among energy companies in new-EU member countries. This is, perhaps, because of the inability to compete with already existing companies throughout the EU and the lack of financial assistance for efforts to attract R&D activities. On the positive side, we find that leverage levels affect innovation in established EU countries, and that a firm’s age provides a proxy for economic credibility in attracting financing for innovation. In this respect, we determined that privately owned companies are able to secure financing for innovation more effectively than state-owned companies because of competition incentives.

In summary, the evidence suggests that leverage and the availability of operating income attract R&D investment in energy companies. New-EU countries are behind their old-EU counterparts in both respects. It would be beneficial to resolve the paucity of financing for R&D in newly established EU countries and less mature companies, which would in turn contribute to sustained R&D activity throughout the EU energy industry. We hope to address this issue in future research.

Appendix 3.A: Detailed Regression estimates for various controls and energy sub-sectors, 1995–2007

Table 3.A.1: A summary of panel estimates of R&D (with an alternative proxy for R&D) with control variables: The energy sector, 1995–2007

	Pooled OLS (without years control) 1	Pooled OLS 2	OLS RE 3	OLS FE 4	First Difference (robust clustered) 5	GMM (inclusion of lagged dependent) 6
Total debt to total assets	0.157 (0.168)	0.124 (0.167)	0.124 (0.0979)	0.116 (0.106)	-0.119 (0.162)	**0.244***** (0.0675)
Total debt to total assets, squared	0.0391 (0.294)	0.0488 (0.295)	0.0488 (0.151)	0.107 (0.163)	0.382 (0.314)	**-0.371***** (0.112)
Operating income	0.0713 (0.0483)	0.0529 (0.0505)	0.0529 (0.0457)	**0.127***** (0.0479)	0.00566 (0.0394)	-0.0129 (0.0351)
Tax to total assets	0.279 (0.227)	0.319 (0.227)	0.319 (0.219)	0.303 (0.231)	-0.243 (0.159)	-0.0792 (0.168)
Liquidity	**0.00891**** (0.00426)	**0.00896**** (0.00417)	**0.00896***** (0.00272)	**0.00648**** (0.00292)	0.00488 (0.0101)	**0.0114***** (0.00270)
Lag of R&D dependent						**0.655***** (0.0443)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.0848***** (0.0234)	**-11.45***** (3.505)	**-11.45***** (3.988)	**-10.82***** (3.982)	0.00353 (0.00374)	-0.819 (23.19)
Threshold debt level	-0.12	-0.20	-0.20	-0.46	1.61	0.76
Observations	1,108	1,108	1,108	1,108	907	1,040
Number of companies	174	174	174	174	158	171
Joint test	0.0005	0.0018	0.0000	0.0000	0.0393	0.0000
Years test		0.0000	0.0004	0.0009		0.0451
Hausman test				0.0004		
Weak-instrument test						0.0000

Note: White's standard errors were applied to control for heteroscedasticity.

This table is similar to Table 3.9 but now with an alternative R&D proxy. This table presents corporate leverage (H1) and operating income (H2) in relation to innovation, with controls for tax shields and liquidity. The regression results are based on various specifications for panel data estimation. The regression methodology was performed as discussed in Chapter 2. The alternative dependent R&D proxy is defined as the ratio of 'R&D expenditure to total sales'. The dependent and explanatory variable definitions are presented in Sections 3.3.1-3.3.3. The joint test, years test and weak-instrument test are presented as 'Prob>F'. The legends (*) to the right of the coefficients denote the significance levels (* p<0.1; ** p<0.05; *** p<0.01).

Table 3.A.2: Summary of panel estimates of R&D (with alternative leverage proxy): Energy sector with inclusion of control variables, 1995–2007

	Pooled OLS (without years control) 1	Pooled OLS 2	OLS RE 3	OLS FE 4	First Difference (robust clustered) 5	GMM (inclusion of lagged dependent) 6
Total liabilities to total assets	**-0.557***** (0.132)	**-0.551***** (0.132)	**-0.551***** (0.0773)	**-0.420***** (0.0835)	-0.123 (0.144)	**-0.183***** (0.0618)
Total liabilities to total assets, squared	**-0.461***** (0.111)	**-0.449***** (0.111)	**-0.449***** (0.0745)	**-0.366***** (0.0792)	-0.128 (0.132)	**-0.150***** (0.0556)
Operating income	**-0.0833***** (0.0316)	**-0.0904***** (0.0317)	**-0.0904***** (0.0259)	**-0.0579**** (0.0269)	0.00912 (0.0360)	**-0.0719***** (0.0245)
Tax to total assets	0.0482 (0.0928)	0.0663 (0.0907)	0.0663 (0.139)	-0.000162 (0.142)	-0.0715 (0.0922)	0.0174 (0.124)
Liquidity	-0.000889 (0.00150)	-0.000945 (0.00153)	**-0.000945*** (0.000552)	**-0.00160***** (0.000612)	0.00113 (0.00116)	**0.00216***** (0.000496)
Lag of R&D dependent						**0.651***** (0.0373)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.260***** (0.0403)	**-5.282**** (2.294)	**-5.282*** (2.845)	-4.088 (2.854)	0.00243 (0.00274)	**33.96*** (17.48)
Threshold Liabilities level	-0.41	-0.41	-0.41	-0.44	-0.52	-0.41
Observations	1,333	1,333	1,333	1,333	1,093	1,259
Number of companies	219	219	219	219	191	213
Joint test	0.0000	0.0000	0.0000	0.0000	0.6033	0.0000
Years test		0.0025	0.1233	0.2146		0.6397
Hausman test				0.0000		
Weak-instrument test						0.0000

Note: White's standard errors were applied to control for heteroscedasticity.

This table is similar to Table 3.9 but now with an alternative leverage proxy. As in the initial table, these data show the effects of corporate leverage (H1) and operating income (H2) on innovation, with controls for tax shields and liquidity. The regression results are based on various specifications for data estimation. The regression methodology was performed as discussed in Chapter 2. The alternative dependent leverage proxy was defined as the ratio of 'total liabilities to total assets'. The dependent and explanatory definitions are presented in Sections 3.3.1-3.3.3. The joint test, years test and weak-instrument test are presented as 'Prob>F'. The legends (*) to the right of the coefficients denote the significance levels (* p<0.1; ** p<0.05; *** p<0.01).

Table 3.A.3: Panel estimates for R&D: Utilities sector with leverage levels, 1995–2007

	Pooled OLS (without years control)	Pooled OLS	OLS RE	OLS FE	First Difference (robust clustered)	GMM (inclusion of lagged dependent)
	1	2	3	4	5	6
A. Tendency to finance with balance sheet (ratio <0.5)						
Total debt to total assets	**0.101*****	**0.0746*****	**0.0746*****	**0.0780*****	-0.0292	-0.0203
	(0.0273)	(0.0253)	(0.0225)	(0.0244)	(0.0393)	(0.0156)
Operating income	-0.161	**-0.205****	**-0.205****	**-0.173***	**-0.177****	-0.0292
	(0.103)	(0.0983)	(0.0861)	(0.0957)	(0.0860)	(0.0723)
Tax to total assets	**0.308***	0.140	0.140	0.211	0.0935	0.0570
	(0.173)	(0.163)	(0.195)	(0.201)	(0.129)	(0.201)
Liquidity	-0.00367	-0.00262	-0.00262	-0.00259	-0.0118	0.00132
	(0.00411)	(0.00410)	(0.00296)	(0.00309)	(0.0112)	(0.00287)
Lag of R&D dependent						**0.751*****
						(0.0390)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.0616*****	**-8.781*****	**-8.781*****	**-8.881*****	-0.000443	18.50
	(0.0136)	(2.283)	(2.242)	(2.269)	(0.00680)	(15.91)
Observations	573	573	573	573	481	557
Number of companies	91	91	91	91	83	91
Joint test	0.0000	0.0006	0.0001	0.0005	0.0808	0.0000
Years test		0.0000	0.0000	0.0001		
Hausman test				0.09265		0.4173
Weak-instrument test						0.0000
B. Tendency to finance with external debt (ratio >=0.5)						
Total debt to total assets	**-0.0594*****	-0.0267	-0.0267	-0.0196	**-0.0813****	-0.0334
	(0.0224)	(0.0345)	(0.0270)	(0.0279)	(0.0357)	(0.0477)
Operating income	-0.00988	-0.0192	-0.0192	-0.0180	**-0.0290*****	-0.0899
	(0.0125)	(0.0123)	(0.0211)	(0.0215)	(0.0107)	(0.0623)
Tax to total assets	**0.326****	0.287	0.287	0.302	0.00464	-0.0100
	(0.136)	(0.205)	(0.223)	(0.227)	(0.120)	(0.551)
Liquidity	-0.00229	-0.00334	-0.00334	-0.00518	0.00311	**0.0450*****
	(0.00441)	(0.00418)	(0.00498)	(0.00514)	(0.00734)	(0.0102)
Lag of R&D dependent						**0.577*****
						(0.124)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.136*****	0	0	**12.86*****	0.0248	13.00
	(0.0311)	(0)	(0)	(4.519)	(0.0247)	(43.18)
Observations	76	76	76	76	67	73
Number of companies	31	31	31	31	30	30
Joint test	0.0033	0.0252	0.3097	0.3544	0.0000	0.0000
Years test		0.0000	0.0001	0.0227		0.0695
Hausman test				0.9980		
Weak-instrument test						0.0000

Note: White's standard errors were applied to control for heteroscedasticity.

This table is a continuation of Table 3.11 that concentrates on the utilities sector. As in Table 3.10, the regression results are based on various specifications for data estimation. The regression methodology was performed as discussed in Chapter 2. The main dependent R&D proxy is defined as the ratio of 'R&D expenditure to total assets'. The dependent and explanatory definitions are presented in Sections 3.3.1-3.3.3. The joint test, years test and weak-instrument test are presented as 'Prob>F'. The legends (*) to the right of the coefficients denote the significance levels (* p<0.1; ** p<0.05; *** p<0.01).

Table 3.A.4: Panel estimates of R&D: Oil and gas sectors with leverage levels, 1995–2007

	Pooled OLS (without years control) 1	Pooled OLS 2	OLS RE 3	OLS FE 4	First Difference (robust clustered) 5	GMM (inclusion of lagged dependent) 6
A. Tendency to finance with balance sheet (ratio <0.5)						
Total debt to total assets	0.0447 (0.0576)	0.0294 (0.0575)	0.0294 (0.0544)	0.0478 (0.0564)	-0.0987 (0.0854)	0.0229 (0.0354)
Operating income	0.0730 (0.0463)	0.0743 (0.0479)	**0.0743*** (0.0434)	**0.103**** (0.0450)	0.0248 (0.0463)	**0.0838**** (0.0378)
Tax to total assets	0.0666 (0.233)	0.265 (0.240)	0.265 (0.287)	0.0674 (0.301)	-0.165 (0.164)	**0.327**** (0.164)
Liquidity	0.00181 (0.00185)	0.00174 (0.00197)	0.00174 (0.00118)	0.00191 (0.00125)	0.00168 (0.00131)	0.000776 (0.000730)
Lag of R&D dependent						**0.826***** (0.0533)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.101***** (0.0347)	-6.058 (4.122)	-6.058 (4.768)	-4.015 (4.804)	-0.00919 (0.00950)	**58.46*** (32.49)
Observations	317	317	317	317	255	297
Number of companies	58	58	58	58	49	57
Joint test	0.4560	0.4944	0.2338	0.0753	0.0164	0.0000
Years test		0.6177	0.7010	0.7650		0.6995
Hausman test				0.6664		
Weak-instrument test						0.0000
B. Tendency to finance with external debt (ratio >=0.5)						
Not enough observations						

Note: White's standard errors were applied to control for heteroscedasticity.

This table is a continuation of Table 3.11 but rather concentrates on oil and gas production. As in Table 3.10, the regression results are based on various specifications for data estimation. The regression methodology was performed as discussed in Chapter 2. The main dependent R&D proxy was defined as the ratio of 'R&D expenditure to total assets'. The definitions of dependent and explanatory measures are presented in Sections 3.3.1-3.3.3. The joint test, years test and weak-instrument tests are presented as 'Prob>F'. The legends (*) to the right of the coefficients denote the significance levels (* p<0.1; ** p<0.05; *** p<0.01).

Table 3.A.5: Panel estimates of R&D: The energy sector with additional controls for firm age, 1995–2007

	Pooled OLS (without years control)	Pooled OLS	OLS RE	OLS FE	First Difference (robust clustered)	GMM (inclusion of lagged dependent)
	1	2	3	4	5	6
1. Firm age (<5 years)						
Total debt to total assets	0.0078	-0.00269	-0.00269	-0.01	-0.0784	0.0093
	(0.0680)	(0.0699)	(0.0992)	(0.1060)	(0.0858)	(0.0827)
Total debt to total assets, squared	-0.0408	-0.057	-0.057	-0.0413	0.0686	-0.035
	(0.0760)	(0.0820)	(0.1340)	(0.1430)	(0.0902)	(0.1250)
Operating income	-0.0218	-0.0381	-0.0381	-0.0165	-0.0567	-0.0254
	(0.0412)	(0.0444)	(0.0398)	(0.0439)	(0.0369)	(0.0384)
Tax to total assets	0.175	0.317	0.317	0.404	-0.124	-0.184
	(0.2370)	(0.2470)	(0.3130)	(0.3280)	(0.2040)	(0.2740)
Liquidity	0.00249	0.00158	0.00158	0.000643	-0.00333	0.00127
	(0.0051)	(0.0051)	(0.0027)	(0.0029)	(0.0073)	(0.0023)
Lag of R&D dependent						**0.736*** **
						(0.0702)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.107*** **	**-11.30** **	**-11.30** **	**-10.40* **	0.000947	**85.00** **
	(0.0259)	(5.2020)	(5.5680)	(5.8980)	(0.0125)	(38.2600)
Threshold debt level	0.10	-0.02	-0.02	-0.12	0.57	0.13
Observations	243	243	243	243	162	224
Number of companies	79	79	79	79	57	75
Joint test	0.8443	0.4501	0.5497	0.7729	0.7031	0.0000
Years test		0.0781	0.2522	0.1761		0.4537
Hausman test				1.0000		
Weak-instrument test						0.0000
2. Firm age (6-10 years)						
Total debt to total assets	-0.115	-0.0842	-0.0842	0.194	0.0849	0.0734
	(0.2490)	(0.2600)	(0.1810)	(0.1790)	(0.0812)	(0.0724)
Total debt to total assets, squared	0.169	0.141	0.141	-0.166	-0.0452	-0.077
	(0.3640)	(0.3780)	(0.2840)	(0.2740)	(0.1090)	(0.1180)
Operating income	-0.0574	-0.0777	-0.0777	0.00857	0.00172	-0.0103
	(0.0545)	(0.0607)	(0.0646)	(0.0592)	(0.0160)	(0.0306)
Tax to total assets	0.114	-0.0326	-0.0326	-0.157	-0.0958	-0.114
	(0.3010)	(0.3360)	(0.4380)	(0.4680)	(0.3670)	(0.2040)
Liquidity	-0.00749	-0.00801	**-0.00801** **	**-0.0117*** **	0.00864	**0.00450*** **
	(0.0069)	(0.0072)	(0.0031)	(0.0030)	(0.0055)	(0.0016)
Lag of R&D dependent						**0.865*** **
						(0.0405)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.133*** **	-4.306	-4.306	0.892	-0.000974	-1.634
	(0.0420)	(4.6290)	(7.5090)	(7.2650)	(0.0032)	(22.5400)
Threshold debt level	0.34	0.30	0.30	0.58	0.94	0.48
Observations	206	206	206	206	174	199
Number of companies	69	69	69	69	57	65
Joint test	0.4304	0.2556	0.1257	0.0013	0.3086	0.0000
Years test		0.5300	0.9664	0.7385		0.8099
Hausman test				0.0005		
Weak-instrument test						0.0000
3. Firm age (11-15 years)						
Total debt to total assets	**-0.253* **	**-0.250* **	**-0.250** **	**-0.294** **	**-0.427** **	-0.0985
	(0.1440)	(0.1440)	(0.1110)	(0.1150)	(0.2000)	(0.0772)
Total debt to total assets, squared	**0.454* **	**0.447* **	**0.447** **	**0.417** **	**0.742** **	**0.256* **
	(0.2550)	(0.2550)	(0.1920)	(0.1920)	(0.3520)	(0.1450)
Operating income	-0.101	-0.0991	-0.0991	0.0062	-0.139	**-0.198*** **
	(0.0723)	(0.0816)	(0.0632)	(0.0626)	(0.0875)	(0.0554)
Tax to total assets	0.0116	0.0194	0.0194	0.0191	**-0.438** **	**-0.548*** **
	(0.2140)	(0.2530)	(0.1980)	(0.1950)	(0.2070)	(0.2090)
Liquidity	-0.000285	-0.000275	-0.000275	1.03E-06	4.94E-05	**-0.00242*** **
	(0.0004)	(0.0005)	(0.0007)	(0.0007)	(0.0001)	(0.0005)
Lag of R&D dependent						**0.825*** **
						(0.0542)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.0989*** **	-0.884	-0.884	0.302	0.0036	2.329
	(0.0263)	(4.2340)	(5.3310)	(6.8210)	(0.0033)	(22.7300)

Threshold debt level	0.28	0.28	0.28	0.35	0.29	0.19
Observations	168	168	168	168	134	153
Number of companies	59	59	59	59	53	58
Joint test	0.2301	0.3494	0.1678	0.2126	0.1327	0.0000
Years test		0.7760	0.9145	0.6199		0.9166
Hausman test				0.0001		
Weak-instrument test						0.0000
4. Firm age (16-25 years)						
Total debt to total assets	-0.272	-0.26	-0.26	-0.164	0.137	0.144
	-0.181	-0.227	-0.224	-0.278	-0.202	-0.117
Total debt to total assets, squared	0.298	0.28	0.28	0.185	-0.285	-0.291
	(0.2340)	(0.3060)	(0.3550)	(0.4210)	(0.2630)	(0.1880)
Operating income	-0.105	-0.0899	**-0.0899***	-0.0467	-0.0728	**-0.0865****
	(0.0878)	(0.0984)	(0.0539)	(0.0552)	(0.0535)	(0.0339)
Tax to total assets	0.362	0.41	0.41	0.00827	0.307	0.0973
	(0.5050)	(0.4960)	(0.5210)	(0.5850)	(0.3110)	(0.2880)
Liquidity	-0.000767	1.92E-05	1.92E-05	-0.000318	0.00277	0.00308
	(0.0024)	(0.0025)	(0.0022)	(0.0022)	(0.0035)	(0.0024)
Lag of R&D dependent						**0.593*****
						(0.0473)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.125*****	3.881	3.881	10.14	-0.00109	-0.936
	(0.0446)	(7.8400)	(16.4900)	(16.8400)	(0.0049)	(31.3300)
Threshold debt level	0.46	0.46	0.46	0.44	0.24	0.25
Observations	146	146	146	146	132	140
Number of companies	39	39	39	39	36	38
Joint test	0.5264	0.6211	0.1789	0.8968	0.3497	0.0000
Years test		0.2873	0.8455	0.6287		0.2613
Hausman test				0.0000		
Weak-instrument test						0.0000
5. Firm age (26-45 years)						
Total debt to total assets	**0.669*****	**0.631****	**0.631****	0.213	**0.686*****	**0.402*****
	(0.1590)	(0.2930)	(0.3160)	(0.2040)	(0.2200)	(0.1350)
Total debt to total assets, squared	**-0.893*****	-0.751	-0.751	-0.233	**-1.086*****	**-0.677*****
	(0.2740)	(0.4670)	(0.5070)	(0.3170)	(0.3580)	(0.2120)
Operating income	0.177	-0.368	**-0.368***	**0.469*****	**0.431*****	**0.471*****
	(0.1840)	(0.4420)	(0.1890)	(0.1240)	(0.0880)	(0.1130)
Tax to total assets	0.107	0.134	0.134	0.0133	0.124	**0.959*****
	(0.1560)	(0.3370)	(0.4300)	(0.2380)	(0.1330)	(0.2030)
Liquidity	**0.00590*****	**0.00613*****	**0.00613*****	0.0082	**0.00357*****	**0.00582*****
	(0.0013)	(0.0009)	(0.0023)	(0.0224)	(0.0012)	(0.0011)
Lag of R&D dependent						**0.846*****
						(0.0660)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	-0.00714	-2.631	-2.631	-11.99	-0.00201	41.93
	(0.0478)	(6.6190)	(15.3600)	(8.6900)	(0.0063)	(42.7600)
Threshold debt level	0.37	0.42	0.42	0.46	0.32	0.30
Observations	83	83	83	83	72	82
Number of companies	17	17	17	17	17	17
Joint test	0.0000	0.0000	0.0125	0.0004	0.0000	0.0000
Years test		0.0002	0.6727	0.1040		0.6140
Hausman test				0.0001		
Weak-instrument test						0.0000
6. Firm age (46-65 years)						
Total debt to total assets	0.0473	0.218	0.218	0.0421	-0.0128	0.155
	(0.1190)	(0.1720)	(0.1880)	(0.1740)	(0.0849)	(0.0976)
Total debt to total assets, squared	0.0957	-0.124	-0.124	0.157	0.0912	-0.158
	(0.1810)	(0.2700)	(0.2690)	(0.2330)	(0.1230)	(0.1590)
Operating income	**-0.276*****	-0.111	-0.111	**-0.316****	-0.0219	0.107
	(0.1010)	(0.1520)	(0.1490)	(0.1370)	(0.0434)	(0.0850)
Tax to total assets	-0.509	-0.559	-0.559	-0.0135	-0.246	-0.343
	(0.4380)	(0.6220)	(0.5330)	(0.4740)	(0.2750)	(0.2890)
Liquidity	0.0248	0.0222	0.0222	-0.0234	-0.000175	**0.0269****
	(0.0167)	(0.0190)	(0.0240)	(0.0219)	(0.0073)	(0.0105)
Lag of R&D dependent						**0.758*****
						(0.0745)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	0.0256	**-8.854****	**-8.854****	**-10.42*****	0.0178	-25.26
	(0.0258)	(3.8120)	(3.8160)	(2.9760)	(0.0180)	(22.7900)
Threshold debt level	-0.25	0.88	0.88	-0.13	0.07	0.49

Observations	91	91	91	91	80	90
Number of companies	15	15	15	15	13	15
Joint test	0.0011	0.0069	0.0731	0.0177	0.8263	0.0000
Years test		0.0340	0.4292	0.0251		0.0951
Hausman test				0.0001		
Weak-instrument test						0.0001
7. Firm age (66-85 years)						
Total debt to total assets	**0.601****	**0.502****	**0.502****	0.414	0.573	**0.264****
	(0.2600)	(0.2220)	(0.2440)	(0.3610)	(0.4280)	(0.1250)
Total debt to total assets, squared	**-1.118****	-0.883	**-0.883***	-1.045	**-1.494****	**-0.703****
	(0.5460)	(0.5700)	(0.5360)	(0.6550)	(0.7310)	(0.2720)
Operating income	-0.356	**-0.847****	**-0.847*****	-0.393	0.137	-0.000154
	(0.3400)	(0.3770)	(0.2830)	(0.3280)	(0.1440)	(0.1510)
Tax to total assets	-0.542	-0.511	-0.511	-0.397	-0.116	0.39
	(0.3620)	(0.5280)	(0.5330)	(0.4650)	(0.0920)	(0.2670)
Liquidity	-0.0098	0.00734	0.00734	-0.0181	0.00034	0.000323
	(0.0108)	(0.0162)	(0.0141)	(0.0116)	(0.0066)	(0.0072)
Lag of R&D dependent						**0.945*****
						(0.0636)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	0.0266	**-23.11****	**-23.11****	**-21.08****	**0.00955****	-29.67
	(0.0347)	(11.0700)	(11.5100)	(9.9870)	(0.0044)	(53.0700)
Threshold debt level	0.27	0.28	0.28	0.20	0.19	0.19
Observations	87	87	87	87	76	85
Number of companies	10	10	10	10	9	10
Joint test	0.0113	0.0077	0.0037	0.1123	0.1126	0.0000
Years test		0.6147	0.7500	0.1813		0.7494
Hausman test				0.0010		
Weak-instrument test						0.0000
8. Firm age (86-105 years)						
Total debt to total assets	-0.253	**-0.445***	**-0.445*****	**-0.467****	-0.0373	0.037
	(0.2690)	(0.2490)	(0.1690)	(0.1800)	(0.2580)	(0.1160)
Total debt to total assets, squared	-0.0801	0.0473	0.0473	0.0533	-0.195	-0.217
	(0.4750)	(0.4310)	(0.3060)	(0.3260)	(0.3130)	(0.2100)
Operating income	0.12	0.112	0.112	0.129	0.0411	-0.0943
	(0.1790)	(0.1760)	(0.1610)	(0.1760)	(0.1190)	(0.0944)
Tax to total assets	0.779	**1.001****	**1.001****	**1.020****	0.316	0.231
	(0.4810)	(0.4350)	(0.4320)	(0.4630)	(0.3890)	(0.3110)
Liquidity	**-0.0228*****	**-0.0248*****	**-0.0248*****	**-0.0258*****	**-0.0251*****	0.00651
	(0.0075)	(0.0065)	(0.0069)	(0.0074)	(0.0036)	(0.0101)
Lag of R&D dependent						**0.924*****
						(0.0295)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.185*****	-0.33	-0.33	-0.017	0.00218	38.03
	(0.0502)	(3.2720)	(4.2660)	(4.5350)	(0.0039)	(42.0100)
Threshold debt level	-1.58	4.70	4.70	4.38	-0.10	0.09
Observations	87	87	87	87	77	85
Number of companies	14	14	14	14	12	14
Joint test	0.0011	0.0000	0.0000	0.0001	0.0000	0.0000
Years test		0.0030	0.0831	0.1591		0.0833
Hausman test				0.0002		
Weak-instrument test						0.0000
9. Firm age (106+ years)						
Total debt to total assets	**0.953****	**1.159*****	**1.159*****	**1.287*****	0.766	**0.844*****
	(0.4160)	(0.2720)	(0.2150)	(0.4650)	(0.5570)	(0.2100)
Total debt to total assets, squared	**-1.702****	**-2.131*****	**-2.131*****	**-2.141*****	**-1.703****	**-1.649*****
	(0.7280)	(0.4760)	(0.3820)	(0.7400)	(0.8130)	(0.3780)
Operating income	**-0.858****	**-1.877*****	**-1.877*****	-0.336	-0.232	**-0.963*****
	(0.3890)	(0.2850)	(0.2520)	(0.3980)	(0.5360)	(0.2920)
Tax to total assets	0.648	-0.754	-0.754	0.747	0.793	-0.0743
	(0.6090)	(0.7560)	(0.8070)	(0.6860)	(0.5780)	(0.8310)
Liquidity	0.0459	0.0223	0.0223	**0.0474*****	0.0656	**0.0308****
	(0.0349)	(0.0281)	(0.0143)	(0.0161)	(0.0463)	(0.0133)
Lag of R&D dependent						**0.470*****
						(0.1050)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	0.0238	**-21.88*****	**-21.88****	-10.51	0.0055	95.02
	(0.0787)	(7.6070)	(9.8190)	(7.4510)	(0.0075)	(72.0100)
Threshold debt level	0.28	0.27	0.27	0.30	0.22	0.26
Observations	80	80	80	80	69	78
Number of companies	15	15	15	15	15	15
Joint test	0.0678	0.0000	0.0000	0.0080	0.1045	0.0000

Years test	0.0057	0.1016	0.4892	0.0674
Hausman test			0.0000	
Weak-instrument test				0.0001

Note: White’s standard errors were applied to control for heteroscedasticity.

This table presents detailed information on the age groups as presented in Table 3.13. As in Table 3.13, the regression results are based on various specifications for data estimation (refer to Chapter 2). The main dependent R&D proxy is defined as the ratio of ‘R&D expenditure to total assets’. The dependent and explanatory definitions are presented in Sections 3.3.1-3.3.3. The joint test, years test and weak-instrument test are presented as ‘Prob>F’. The legends (*) to the right of the coefficients denote the significance levels (* p<0.1; ** p<0.05; *** p<0.01).

Table 3.A.6: Panel estimates of R&D: Utilities with additional controls for ownership type, 1995–2007

	Pooled OLS (without years control) 1	Pooled OLS 2	OLS RE 3	OLS FE 4	First Difference (robust clustered) 5	GMM (inclusion of lagged dependent) 6
A. 'Private' ownership						
Total debt to total assets	**0.154****	**0.129****	**0.129****	**0.114***	0.0453	**0.119****
	(0.0647)	(0.0606)	(0.0567)	(0.0588)	(0.0804)	(0.0515)
Total debt to total assets, squared	**-0.178****	**-0.154***	**-0.154***	**-0.139***	-0.104	**-0.239*****
	(0.0870)	(0.0833)	(0.0834)	(0.0857)	(0.0879)	(0.0888)
Operating income	-0.0223	-0.0307	-0.0307	-0.0150	-0.0181	-0.0386
	(0.0345)	(0.0324)	(0.0439)	(0.0450)	(0.0137)	(0.0419)
Tax to total assets	**0.399*****	**0.284***	0.284	0.293	0.154	0.168
	(0.153)	(0.147)	(0.192)	(0.196)	(0.121)	(0.199)
Liquidity	-0.000732	0.000254	0.000254	0.000170	-0.00193	**0.00520***
	(0.00593)	(0.00580)	(0.00298)	(0.00308)	(0.0115)	(0.00298)
Lag of R&D dependent						**0.751*****
						(0.0373)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.0625*****	**-5.979****	**-5.979****	**-5.897****	0.00353	**31.46***
	(0.0160)	(2.547)	(2.546)	(2.568)	(0.00231)	(17.37)
Threshold Debt Level	0.43	0.42	0.42	0.41	0.22	0.25
Observations	533	533	533	533	449	514
Number of companies	77	77	77	77	70	76
Joint test	0.0058	0.0284	0.0738	0.0981	0.1170	0.0000
Years test		0.0027	0.0116	0.0116		0.0387
Hausman test				0.0979		
Weak-instrument test						0.0000
B. 'State' ownership						
Total debt to total assets	**0.550*****	**0.347****	**0.347****	**0.144***	**-0.268***	**0.209***
	(0.131)	(0.135)	(0.166)	(0.201)	(0.162)	(0.114)
Total debt to total assets, squared	**-0.721*****	**-0.427****	-0.427	-0.0978	0.318	**-0.342***
	(0.200)	(0.214)	(0.279)	(0.316)	(0.223)	(0.189)
Operating income	-0.223	-0.0820	-0.0820	-0.137	-0.261	-0.0439
	(0.272)	(0.260)	(0.263)	(0.265)	(0.166)	(0.209)
Tax to total assets	-0.0719	0.486	0.486	**1.034***	0.255	-0.275
	(0.547)	(0.443)	(0.610)	(0.621)	(0.354)	(0.462)
Liquidity	**0.0238****	0.00980	0.00980	-0.00569	0.0151	**0.0166***
	(0.0106)	(0.0106)	(0.0126)	(0.0150)	(0.0134)	(0.00865)
Lag of R&D dependent						**0.782*****
						(0.0789)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	-0.0260	**-14.25*****	**-14.25*****	**-15.93*****	**0.00913****	-29.31
	(0.0201)	(3.772)	(5.420)	(5.346)	(0.00450)	(29.66)
Threshold Debt Level	0.38	0.41	0.41	0.74	0.42	0.31
Observations	116	116	116	116	99	116
Number of companies	17	17	17	17	17	17
Joint test	0.0005	0.0748	0.1821	0.1837	0.2214	0.0000
Years test		0.0000	0.0044	0.0019		0.0822
Hausman test				0.0001		
Weak-instrument test						0.0000

Note: White's standard errors were applied to control for heteroscedasticity.

This table advances on Table 3.12 by providing the ownership distribution for the utilities sector. As before, the regression results are based on various specifications for data estimation. The main dependent R&D proxy is defined as the ratio of 'R&D expenditure to total assets'. The dependent and explanatory variable definitions are presented in Section 3.3.1.-3.3.3. The joint test, years test and weak-instrument test are presented as 'Prob>F'. The legends (*) to the right of the coefficients denote the significance levels (* p<0.1; ** p<0.05; *** p<0.01).

Table 3.A.7: Panel estimates of R&D: Oil and gas producers with additional control for ownership type, 1995–2007

	Pooled OLS (without years control) 1	Pooled OLS 2	OLS RE 3	OLS FE 4	First Difference (robust clustered) 5	GMM (inclusion of lagged dependent) 6
A. 'Private' ownership						
Total debt to total assets	**0.323*** (0.188)	0.309 (0.189)	**0.309*** (0.174)	**0.520***** (0.188)	**0.452*** (0.267)	0.0738 (0.0977)
Total debt to total assets, squared	**-0.694**** (0.296)	**-0.716**** (0.299)	**-0.716**** (0.302)	**-1.046***** (0.334)	**-0.975**** (0.405)	-0.127 (0.170)
Operating income	-0.0115 (0.0628)	-0.0140 (0.0601)	-0.0140 (0.0468)	0.0429 (0.0489)	0.0219 (0.0473)	-0.00111 (0.0377)
Tax to total assets	0.0970 (0.195)	0.216 (0.200)	0.216 (0.266)	0.0772 (0.276)	-0.0559 (0.138)	0.201 (0.174)
Liquidity	**-0.00384*** (0.00222)	**-0.00381*** (0.00228)	**-0.00381***** (0.00112)	**-0.00452***** (0.00113)	0.00243 (0.00150)	0.00104 (0.000756)
Lag of R&D dependent						**0.764***** (0.0461)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.134***** (0.0389)	-7.565 (5.090)	-7.565 (6.237)	-4.984 (6.208)	-0.00936 (0.0103)	**58.90*** (33.71)
Threshold Debt Level	0.23	0.22	0.22	0.25	0.23	0.29
Observations	322	322	322	322	247	297
Number of companies	64	64	64	64	51	60
Joint test	0.0225	0.0159	0.0023	0.0002	0.0000	0.0000
Years test		0.3440	0.6580	0.6397		0.6467
Hausman test				0.0001		
Weak-instrument test						0.0001
B. 'State' ownership						
Total debt to total assets	**0.230***** (0.0419)	**0.272***** (0.0605)	**0.272***** (0.0595)	**0.192*** (0.164)	-0.163 (0.151)	0.164 (0.151)
Total debt to total assets, squared	**-0.592***** (0.107)	**-0.687***** (0.209)	**-0.687***** (0.197)	0.222 (0.349)	0.118 (0.270)	-0.520 (0.327)
Operating income	0.164 (0.110)	0.195 (0.141)	0.195 (0.144)	-0.00378 (0.127)	0.0383 (0.113)	0.119 (0.211)
Tax to total assets	0.251 (0.203)	0.177 (0.260)	0.177 (0.274)	0.141 (0.207)	**0.357*** (0.191)	0.171 (0.363)
Liquidity	**-0.0249*** (0.0134)	**-0.0257*** (0.0143)	**-0.0257*** (0.0136)	**-0.0260**** (0.0105)	**-0.0263*** (0.0137)	-0.0314 (0.0193)
Lag of R&D dependent						0.356 (0.423)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	0.0331 (0.0218)	2.101 (1.794)	2.101 (1.910)	-0.344 (1.652)	0.000419 (0.00227)	-9.573 (24.78)
Threshold Debt Level	0.19	0.20	0.20	0.43	0.69	0.16
Observations	26	26	26	26	23	26
Number of companies	3	3	3	3	3	3
Joint test	0.0000	0.0000	0.0000	0.0174	0.2060	0.0104
Years test		0.0000	0.0203	0.0183		0.0574
Hausman test				0.0896		
Weak-instrument test						0.0001

Note: White's standard errors were applied to control for heteroscedasticity.

This table advances on Table 3.13 by providing ownership distribution results for oil and gas producers. As before the regression results based on various methods for data estimation. The regression methodology was performed as discussed in Chapter 2. The main dependent R&D proxy is defined as the ratio of 'R&D expenditure to total assets'. The dependent and explanatory measures definitions are presented in Sections 3.3.1-3.3.3. The joint test, years test and weak-instrument test are presented as 'Prob>F'. The legends (*) to the right of the coefficients denote the significance levels (* p<0.1; ** p<0.05; *** p<0.01).

Table 3.A.8: Panel estimates of R&D: Utilities with additional control for EU integration, 1995–2007

	Pooled OLS (without years control) 1	Pooled OLS 2	OLS RE 3	OLS FE 4	First Difference (robust clustered) 5	GMM (inclusion of lagged dependent) 6
A. 'Old' EU countries (joined prior to 2004)						
Total debt to total assets	**0.235****	**0.192***	**0.192****	**0.239*****	0.0773	**0.0272***
	(0.119)	(0.113)	(0.0795)	(0.0840)	(0.0828)	(0.0568)
Total debt to total assets, squared	-0.155	-0.155	-0.155	-0.210	-0.0876	-0.00991
	(0.192)	(0.188)	(0.130)	(0.135)	(0.125)	(0.106)
Operating income	**-0.439*****	**-0.408*****	**-0.408*****	**-0.371*****	**-0.237***	-0.0378
	(0.129)	(0.119)	(0.120)	(0.125)	(0.130)	(0.100)
Tax to total assets	0.0554	-0.0159	-0.0159	0.0133	-0.0517	-0.0581
	(0.201)	(0.189)	(0.208)	(0.212)	(0.157)	(0.217)
Liquidity	**-0.0144****	**-0.0127****	**-0.0127*****	**-0.0137*****	**-0.0260****	-0.00601
	(0.00568)	(0.00606)	(0.00379)	(0.00388)	(0.0107)	(0.00391)
Lag of R&D dependent						**0.947*****
						(0.0414)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.0663*****	0	0	**-9.271*****	**0.00680*****	**26.94***
	(0.0245)	(0)	(0)	(3.107)	(0.00230)	(14.97)
Threshold Debt Level	0.76	0.62	0.62	0.57	0.44	1.37
Observations	331	331	331	331	261	316
Number of companies	66	66	66	66	57	64
Joint test	0.000	0.0000	0.0000	0.0000	0.0536	0.0000
Years test		0.0000	0.0000	0.0029		0.0130
Hausman test				0.0074		
Weak-instrument test						0.0000
B. 'New' EU countries (joined post 2004)						
Total debt to total assets	**0.164****	**0.162****	**0.162***	0.0159	-0.0724	**0.398*****
	(0.0644)	(0.0657)	(0.0832)	(0.0990)	(0.122)	(0.0664)
Total debt to total assets, squared	**-0.206****	**-0.203****	**-0.203***	-0.0464	0.0129	**-0.598*****
	(0.0857)	(0.0857)	(0.108)	(0.122)	(0.119)	(0.105)
Operating income	-0.0256	-0.0286	-0.0286	-0.0129	-0.0180	-0.0582
	(0.0243)	(0.0238)	(0.0453)	(0.0464)	(0.0224)	(0.0424)
Tax to total assets	0.295	0.311	0.311	0.391	**0.338****	0.228
	(0.237)	(0.239)	(0.297)	(0.309)	(0.140)	(0.251)
Liquidity	0.00766	0.00738	**0.00738***	**0.00858****	0.0148	**0.00984*****
	(0.00915)	(0.00899)	(0.00384)	(0.00403)	(0.0131)	(0.00323)
Lag of R&D dependent						**0.254*****
						(0.0719)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.0521*****	0	0	-1.365	0.000953	8.105
	(0.0141)	(0)	(0)	(4.866)	(0.00342)	(14.49)
Threshold Debt Level	0.40	0.40	0.40	0.17	2.81	0.33
Observations	318	318	318	318	287	314
Number of companies	92	92	92	92	86	91
Joint test	0.0669	0.0716	0.1272	0.2325	0.2280	0.0000
Years test		0.0005	0.0310	0.0079		0.0064
Hausman test				0.0092		
Weak-instrument test						0.0002

Note: White's standard errors were applied to control for heteroscedasticity.

This table advances on Table 3.14 by providing EU integration results for utilities. As before the regression results are based on various methods for data estimation. The regression specification was performed as discussed in Chapter 2. The main dependent R&D proxy is defined as the ratio of 'R&D expenditure to total assets'. The dependent and explanatory measures definitions are presented in Sections 3.3.1-3.3.3. The joint test, years test and weak-instrument test are presented as 'Prob>F'. The legends (*) to the right of the coefficients denote the significance levels (* p<0.1; ** p<0.05; *** p<0.01).

Table 3.A.9: Panel estimates of R&D: Oil and gas producers with additional controls for EU integration, 1995–2007

	Pooled OLS (without years control) 1	Pooled OLS 2	OLS RE 3	OLS FE 4	First Difference (robust clustered) 5	GMM (inclusion of lagged dependent) 6
A. 'Old' EU countries (joined prior to 2004)						
Total debt to total assets	-0.103 (0.216)	-0.0847 (0.205)	-0.0847 (0.174)	0.112 (0.193)	0.0834 (0.210)	-0.0281 (0.0970)
Total debt to total assets, squared	0.0606 (0.319)	0.00102 (0.306)	0.00102 (0.306)	-0.257 (0.318)	-0.357 (0.385)	-0.0293 (0.177)
Operating income	-0.0686 (0.101)	-0.0743 (0.106)	-0.0743 (0.0470)	0.00830 (0.0493)	-0.0195 (0.0399)	-0.0315 (0.0310)
Tax to total assets	-0.0757 (0.330)	0.254 (0.335)	0.254 (0.358)	0.315 (0.347)	0.138 (0.105)	0.156 (0.216)
Liquidity	0.00528 (0.00479)	0.00481 (0.00473)	0.00481 (0.00301)	0.00377 (0.00317)	0.00157 (0.00212)	**0.00384**** (0.00180)
Lag of R&D dependent						**1.109***** (0.0543)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.0901**** (0.0370)	0 (0)	0 (0)	**-21.98***** (6.072)	0.00890 (0.00565)	-0.451 (25.82)
Threshold debt level	0.85	41.52	41.52	0.22	0.12	-0.48
Observations	175	175	175	175	139	165
Number of companies	35	35	35	35	33	34
Joint test	0.5737	0.4661	0.0709	0.0065	0.6223	0.0000
Years test		0.0124	0.0010	0.0107		0.0095
Hausman test				0.0001		
Weak-instrument test						0.0000
B. 'New' EU countries (joined after 2004)						
Total debt to total assets	0.264 (0.255)	0.161 (0.259)	0.161 (0.279)	0.450 (0.337)	**0.829**** (0.345)	0.193 (0.154)
Total debt to total assets, squared	**-0.726*** (0.418)	-0.598 (0.410)	-0.598 (0.459)	**-1.131*** (0.576)	**-1.621***** (0.529)	-0.276 (0.256)
Operating income	-0.0307 (0.0676)	-0.0369 (0.0672)	-0.0369 (0.0705)	0.0612 (0.0757)	0.0678 (0.0784)	0.0395 (0.0719)
Tax to total assets	0.365 (0.236)	0.342 (0.231)	0.342 (0.337)	0.177 (0.367)	-0.0443 (0.164)	0.352 (0.234)
Liquidity	-0.00294 (0.00283)	-0.00285 (0.00283)	**-0.00285**** (0.00129)	**-0.00376***** (0.00130)	0.00136 (0.00124)	0.00123 (0.000918)
Lag of R&D dependent						**0.661***** (0.0669)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.158***** (0.0455)	0 (0)	0 (0)	27.22 (18.14)	-0.0157 (0.0119)	53.54 (38.58)
Threshold debt level	0.18	0.13	0.13	0.20	0.26	0.35
Observations	173	173	173	173	131	158
Number of companies	63	63	63	63	50	59
R-squared				0.145		
Joint test	0.3185	0.2688	0.0823	0.0228	0.0000	0.0000
Years test		0.0028	0.0002	0.0378		0.05346
Hausman test				0.0248		
Weak-instrument test						0.0000

Note: White's standard errors were applied to control for heteroscedasticity.

This table advances on Table 3.14 by providing EU integration results for oil and gas producers. As before, the regression results are based on various panel data. The regression specification was performed as discussed in Chapter 2. The main dependent R&D proxy is defined as the ratio of 'R&D expenditure to total assets'. The dependent and explanatory variable definitions are presented in Sections 3.3.1-3.3.3. The joint test, years test and weak-instrument test are presented as 'Prob>F'. The legends (*) to the right of the coefficients denote the significance levels (* $p<0.1$; ** $p<0.05$; *** $p<0.01$).

Appendix 3.B: Summary of additional R&D measures not included in the modelling, 1995–2007

	Utilities	Oil and gas producers	All sectors
Science and technology: Investment in knowledge as related to GDP ratio	0.02 (0.02)	0.02 (0.02)	0.02 (0.02)
Ratio of R&D intangibles to company employment level	102.57 (268.61)	312.06 (1343.81)	256.57 (3327.42)
Science and technology: Patents, Triadic Patent Families (when patent was applied in all three existing agencies)	1,509 (1868)	1,078 (880)	1,258 (1464)
Number of patents granted by the USPTO by priority year at the national level	50.35 (44.99)	44.73 (31.33)	47.98 (40.87)
R&D of the energy sector as related to the R&D total of a country	0.15 (0.05)	0.15 (0.05)	0.15 (0.05)
Gross domestic expenditure on R&D	0.02 (0.01)	0.01 (0.01)	0.01 (0.01)

Note: Standard deviations are in parentheses ( )

There are other alternative R&D indicators; although these have not been included in the estimates, we give a general overview of the descriptive statistics for a broader understanding of the energy sector.

R&D in human resources

Following Hall (2002), almost half of innovation costs relate directly to the wages and salaries of researchers—scientists, engineers and economists—and hence human resources represent a main source of future income generation. We have broadened this measure by introducing R&D as intangible assets to the number of employees in a company, as this is the information we could obtain from the statistical database. There is, however, another related human capital measure, which is investment in knowledge as related to the GDP ratio (OECD, 2008). The second investment in knowledge as related to the GDP ratio is at the country-level and not the company level, as presented in the first human resource–related index. It is interesting to compare these two ratios, as we would expect them to follow the same pattern for the observed countries, which would support the plausibility of the employed human resource R&D measurements.

A general comparison of the two human resource R&D measures shows that on an average basis across all sectors, the R&D to employment ratio is 257 (a ratio close to 1 shows that there is a minimum input provided by one employed person, while a higher ratio demonstrates the maximum input from every employee). The second measure is a proportion of the investment in knowledge in relation to country GDP level; the higher the ratio, the better, as this represents greater investment in education and knowledge. As the measure is at the country level and not the firm level, the average investments in knowledge are the same for all sectors, at 2% of the GDP, while the standard deviation is 2%, which shows that there are country-to-country variations.

Patents as a measure of R&D

Other authors use the number of patents to demonstrate R&D activity. Trajtenberg (1990) argues that patent-related measures are a better indicator of innovation productivity. We use two types of patent-based R&D, available from Eurostat and OECD Factbook 2008, respectively: (a) patents granted by the USA Patent and Trademark Office (US PTO) by priority year at the national level, and (b) patents granted by a Triadic Patent Family (a patent family is defined as a set of patents taken in various countries (i.e., patent offices) to protect the same invention. Triadic patent families are a set of patents taken at all three of these major patent offices – the European Patent Office (EPO), the Japan Patent Office (JPO) and the USPTO, based on the OECD Factbook 2008 explanation. On a general sample level, we have patent-related data available for almost every country in consecutive years with a mean patent number of 48 registered by the US PTO, and with an average of 1,258 patents registered with the Triadic Patent Family for the same inventions. The largest number of patents obtained in both instances was observed in the utilities sector: 50 (US PTO) and 1,509 (Triadic Patent Family). However, we need to bear in mind that these two patent parameters are not energy-sector specific but rather represent every possible invention within a particular country, which generalises the effect of R&D.

The ratio of energy sector R&D to total R&D for a given country

To measure the degree of investment in the energy sector, we applied the R&D energy share of all countries' sectors based on data available from Research Framework programmes 1-7 covering the 1983–2013 period (European Commission, CORDIS). The R&D energy sector share of each country's total expenditure on R&D is available at the general European level and thus relates to every observed company within a given time period (four consecutive years). According to the CORDIS data, R&D expenditure has dropped from a 22% share in 1995–1998 to a 7% share in 2007–2013.

The ratio of R&D to gross domestic product (GDP)

The fact that energy companies do not restrict themselves to specific countries and tend to internationalise and diversify investment portfolios would allow us to compare gross domestic expenditure to R&D. The relevant data were obtained from the OECD Factbook 2008. Interestingly, there are six countries where there is no R&D expenditure at all: Cyprus, Czech Republic, Lithuania, Latvia, the Netherlands and Romania. The average mean GDP to R&D proxy demonstrates that the highest level is achieved within the utilities sector (0.02), although the ratios were similar for the oil and gas production sector and the overall energy industry (0.01).

Appendix 3.C: Summary of country-level R&D and leverage proxies, 1995–2007

The aim of this chapter is to analyse the European energy companies; we do not analyse individual countries or companies. This work is planned for future analyses. At time, we are aware that the majority of the companies studied are located in the UK, France, Italy, Spain and Germany (refer to Figure 3.2).

Country	R&D expenditure to total assets ratio		R&D expenditure to operating revenues (net sales) ratio		Total debt to total assets ratio		Total liabilities to total assets ratio	
	Mean	St dev	Mean	St dev	Mean	St dev	Mean	St dev
Austria	0.06	(0.07)	0.15	(0.20)	0.25	(0.14)	0.65	(0.11)
Belgium	0.08	(0.17)	0.01	(0.01)	0.40	(0.21)	0.66	(0.17)
Cyprus	0.00	(0.00)	0.01	(0.00)	0.20	(0.12)	0.51	(0.17)
Czech Republic	0.01	(0.01)	0.02	(0.03)	0.10	(0.08)	0.40	(0.14)
Germany	0.06	(0.07)	0.12	(0.17)	0.20	(0.19)	0.69	(0.17)
Denmark	0.09	(0.14)	0.14	(0.27)	0.32	(0.19)	0.51	(0.16)
Estonia	0.01	(0.01)	0.05	(0.02)	0.45	(0.12)	0.52	(0.12)
Spain	0.07	(0.10)	0.14	(0.19)	0.31	(0.14)	0.65	(0.12)
Finland	0.02	(0.01)	0.02	(0.01)	0.30	(0.06)	0.60	(0.06)
France	0.10	(0.12)	0.16	(0.21)	0.21	(0.18)	0.68	(0.18)
UK	0.11	(0.15)	0.15	(0.17)	0.23	(0.18)	0.48	(0.23)
Greece	0.02	(0.03)	0.02	(0.04)	0.29	(0.16)	0.56	(0.18)
Hungary	0.02	(0.01)	0.01	(0.01)	0.19	(0.11)	0.50	(0.10)
Ireland	0.35	(0.30)	0.29	(0.33)	0.12	(0.18)	0.29	(0.21)
Italy	0.10	(0.10)	0.21	(0.23)	0.30	(0.15)	0.61	(0.14)
Lithuania	0.01	(0.03)	0.02	(0.07)	0.15	(0.13)	0.30	(0.12)
Luxemburg	0.01	(0.01)	0.02	(0.01)	0.18	(0.23)	0.49	(0.17)
Latvia	0.05	(0.07)	0.20	(0.26)	0.10	(0.13)	0.26	(0.12)
Netherlands*								
Poland	0.04	(0.11)	0.02	(0.03)	0.16	(0.09)	0.43	(0.10)
Portugal	0.07	(0.05)	0.15	(0.14)	0.34	(0.08)	0.66	(0.11)
Romania	0.02	(0.02)	0.03	(0.04)	0.12	(0.12)	0.40	(0.10)
Sweden	0.12	(0.28)	0.07	(0.11)	0.34	(0.21)	0.59	(0.17)
Slovakia	0.01	(0.01)	0.01	(0.01)	0.15	(0.12)	0.61	(0.26)
All EU-24	0.10	(0.17)	0.13	(0.19)	0.24	(0.18)	0.55	(0.21)

*Netherlands: no observations
Note: S tandard deviations are in parentheses ( ).

In our analyses, we focus on general R&D measures – expenditure to total assets and capital structure – total debt to total assets, as guided by data availability. The standard deviation in all measures is high, which suggests inter-country variability. All R&D and leverage measures were obtained from the OSIRIS dataset.

The highest level of average intangible assets to total assets is observed in Ireland (0.35), followed by Sweden (0.12) and the UK (0.11), with the EU-24 average at 0.08. The highest R&D sales measure was observed for Ireland (0.29) followed by Italy (0.21) and Latvia (0.20); in all other countries, however, the average of this variable is 0.13.

We also compare the sample averages with those obtained by Rajan and Zingales (1995) and Booth et al. (2001)[7]. We report that the energy industry has about the same average debt level as documented by Rajan and Zingales (1995), 0.23. We contrast with Rajan and Zingales in reporting that the liabilities ratio was less than the general country level of 0.66. Booth et al. (2001) found that the average ratio of total liabilities to total assets for a given country was 0.67, which is higher compared to the energy sector data presented here.

[7] Note that both Rajan and Zingales (1995) and Booth et al. (2001) examined only four countries that were included in our sample (Germany, France, the UK and Italy). However, these countries provided the largest amounts of firm data for our research.

CHAPTER 4

4. Does corporate governance reform necessarily boost firm value? Recent evidence from Russia

Abstract

This chapter examines whether the introduction of CG reforms in general and that of T&D rules in particular can necessarily boost firm value. Existing literature suggests that CG reforms can boost value because they can resolve the conflict of interest between the controlling and the minority owners, especially in societies with a highly skewed distribution of ownership. We, however, argue that the success of CG reform would, in addition, depend on whether the reforms may initiate further conflict, for example, conflict between the state and the controlling owners. Using recent data from Russia for 2000–2008, we find that the introduction of CG codes in Russia had limited success in improving indices of firm value in our sample. We argue that this arises from the predatory behaviour of the central and local governments: greater transparency makes businesses easy targets for aggressive tax-enforcement policies from the central government, while the decentralised local governments may increase bribe prices to protect businesses from high central taxes, which may also tempt some businesses to go underground, thus harming firm value.

4.1. Introduction

Existing research suggests that the financial markets are more likely to benefit from external investment if investors enjoy robust legal protection. Both equity and debt investments attract higher prices when CG laws protect the investors against expropriation by controlling owners. By limiting the expropriation through controlling owners, especially when ownership distribution is highly skewed, CG laws may encourage the external financing of corporate investment and, hence, firm value and growth. The question is whether this perceived link between the introduction of CG codes and firm value will, necessarily, always hold. The present chapter tests the validity of this hypothesis by considering large listed corporations in Russia, a country which introduced CG codes in 2002 (and that were made effective from 2004 onwards) amidst a series of other reforms in a radical bid to boost the ailing economy under President Putin.

Russia is a special case in point. Many Russian firms remain family controlled and highly concentrated, leading to large-scale expropriation of small investors including minority shareholders and creditors. Consequently, Russian firms often face difficulties securing external funds and are therefore forced to finance most investment internally (Blasi and Shleifer, 1996). Until 2002, Russia had no recognised accounting standards or other official CG mechanism capable of insuring the type of corporate integrity within companies that stimulates investment incentives and financial markets. Low protection of property rights remained a preferred policy of the rich in a country plagued with a very high degree of income inequality. The result was significant undervaluation of Russian firms, which necessitated the introduction of better CG structures to induce external investment. After years of expropriations of minority shareholders and fierce battles for assets, Russian oligarchs finally began to understand that the only way to sustain the development of their companies was through attracting external funds.

When Mr. Putin succeeded Mr. Yeltsin in March 2000, his goal was to reassert Kremlin control over a chaotic, cash-strapped state. First, there was a radical tax reform in 2001 that strengthened tax administration and enforcement by the centralized state (Desai, Dyck and Zingales, 2007). Next, Russia quickly caught up with the West in adjusting its company and bankruptcy laws to Western standards and it introduced the CG codes in 2002. However, law enforcement remains poor (Pistor et al., 2000), primarily due to widespread corruption in courts, regulatory bodies, and law enforcement agencies and also due to the conflict of interest between central and local governments (Treisman, 2000) in this decentralised framework.[8]

The question that we raise here is whether the introduction of T&D rules in this kind of investment climate can necessarily boost firm value. Despite privatisation, different levels of government still remain as company stakeholders. However, the central government also has a claim on any firm as a tax collector and, as such, there may arise a conflict of interest between the central government as a the stakeholder and its role as a tax collector. While the introduction of T&D rules (and also the overall CG codes) can resolve the conflict of interest between the controlling and minority owners, thus boosting firm value, it may worsen the conflict between the state as the tax collector and the private controlling owners in Russia. In particular, the increasing transparency of businesses may make those firms easy targets for aggressive tax-enforcement policies from the central government and may thus reduce income sheltering or tax evasion strategies.

Heinrich (2006) suggests that many oil and gas sector firms feared that too much transparency would make them vulnerable to attack from Russia's state agencies. The case of Mikhail Khodrokovsky, founder of the Russian oil and gas giant Yukos, who has been convicted of embezzlement, fraud and tax evasion is particularly noteworthy in this context. This involved a conspicuously aggressive case of state predatory behaviour. Further, Treisman (2000) argued that there arose a conflict of interest between the central and local governments in Russia's decentralised economy, which may thwart the central government's objective of lessening tax-evasion strategies. First, in Russia's politically decentralised society, sub-national governments can attract businesses by offering protection against the central government tax collectors, regulators or bankruptcy agencies (Treisman, 2000). Second, greater fiscal decentralisation in a politically decentralised society may lower the incentive of the regional government to protect businesses against paying taxes, but may, in turn, increase the price paid in bribes to protect businesses against central taxes (which, in turn, may act to increase tax for private businesses). Finally, greater fiscal decentralisation may also induce private enterprises to shift part of their output underground, thus adversely affecting the performance of the legal entity. Thus, the objective of firm-value maximization through the introduction of T&D rules may

[8] The distinctive features of the tax reforms of 2001 have been the significant emphasis placed on compliance with tax laws and also the introduction of changes to the administration and enforcement of the laws. In particular, incentives were offered to regional governments to have a greater share of local tax revenue in an attempt to prevent them from protecting local tax payers from paying central taxes. Further, the tax rate on dividends was raised from 15% to 30%, while corporate tax rate remained unchanged at 30% (subsequently, it was reduced to a flat rate of 24%). Thus, desperate government attempts to re-establish control over private businesses through aggressive tax enforcement policies resulted in a war between the state and private businesses.

be compromised by various factors that inherently characterise the Russian political and economic set-up. Accordingly, we argue that the net effect of the introduction of CG reform in Russia could be positive, negative or insignificant (when the positive and negative effects of CG reform outweigh each other).[9] In the absence of any prior evidence in this respect, we empirically explore the effect of the introduction of CG codes in general and that of T&D rules in particular, in Russia.

Our analysis focuses on the largest listed companies in Russia generally for the period 2000–2008[10], the period which witnessed the introduction, implementation and further development of CG codes, along with the reform of tax administration enforcement, and also political and fiscal decentralisation measures. The companies studied are those that are included in S&P's T&D data, covering 80% of the cumulative market capitalisation of the Russian Stock Market in 2007, which were all subject to the newly introduced CG codes. We merge the T&D data compiled by S&P with firm-level accounting data extracted from the OSIRIS database available from the Bureau van Dijk.

T&D data covers six indices on ownership structure, shareholder rights, financial and operational performance, and board and management structure and processes, all of which are important elements that affect a firm's attractiveness to investors. We also use a measure of composite T&D (obtained by using principal component analysis of six available indices), which allows us to test our central hypothesis that better T&D improves a firm's value in Russia. While we do not observe the sample firms' responses to tax reform or their alliances with local governments in order to evade central taxes, it can be argued that these factors are controlled by the firm and year fixed effects in our analysis.

For the purpose of this chapter, we experiment with two measures of firm value as defined by Tobin's Q (Tobin, 1969), which focus on the market valuation of the firm in relation to the cost of capital. In the absence of any prior research in this respect, we use our data to explore this further:

- First, we exploit the inter-firm variation in the adoption of T&D rules (an exogenous policy intervention) to identify the effect of introducing the CG code on firm value; in doing so, we also control for additional firm (e.g., including firm size, leverage, age and market concentration, as measured by the Herfindahl index), sector characteristics, which may otherwise influence firm value.

[9] T&D is a key aspect of the modern CG mechanism and an important element affecting how attractive a firm appears to be in the eyes of potential investors. This is a set of rules, which covers various aspects of corporate practice including a firm's openness about financial and operational information, its ownership structure, and shareholders' rights under the company's governing legal documents, and the capabilities of the individual board members and management.

[10] Note that our analysis using S&P's T&D indices only focused on the period 2003–2007, as this data is only available for this period. Please see the further discussion in the data section.

- Next, we compare the effects of T&D rules (pertaining to ownership structure, shareholder rights, financial and operational performance, and board and management structure and processes) not only on all firms, but also on energy and non-energy sector firms individually in our sample for the period 2003–2007 for which this data is available.
- Finally, we assess the impact of the introduction of the overall CG codes made effective from 2004 onwards on firm value indices in Russia using 2000–2008 data. Note that in this case we are not constrained by 2003–2007 T&D data available from S&P and, hence, we use a slightly larger sample that allows us to extend the end data point to 2008 (the latest year available on OSIRIS when we initiated this research). Accordingly, we replace the T&D rules' indices by a binary indicator of the introduction of CG codes made effective from 2004 onwards. The variable takes a value of 1 for all the years from 2004–2008, but zero otherwise.

However, in order to assess the impact of the CG code over this period, we also need to identify some firms that may be considered as being the control group (i.e., those who were not covered by the introduction of Russian CG codes in 2004). Our analysis in this respect exploits the variation in the adoption of the CG code by those Russian listed firms who were also listed on the international stock exchange. The underlying idea is that in the post-2000 years of rapid Russian recovery and subsequent growth, some Russian listed firms also became listed on international financial markets (mainly on the London Stock Exchange) to raise external finance. These firms would often adopt more stringent international CG codes than those listed only on the Russian Stock Exchange. As such, the adoption of international CG codes by these firms would not necessarily coincide with the introduction of Russian CG codes and, hence, we treat these internationally listed Russian firms as our control group. This allows us to exploit the variation in the adoption of CG codes between domestic and foreign listed companies before and after the effective introduction of Russian CG codes in 2004 with a view to identifying an effect brought about by the introduction of CG codes.

There is evidence from our analysis that both composite T&D rules as well as T&D in financial and operational information significantly boosted the value of firms, particularly for utility firms in our sample. However, the effect of T&D of any kind remains insignificant in terms of explaining firm value[11] among oil and gas companies, which hold a particularly prominent place in the Russian economy (see the further

[11] Among the two measures of firm value (EBIT and market valuation based Tobin's Q), we find that the effect of T&D indices on EBIT as a share of total assets is always insignificant; hence, our analysis is essentially based on the results obtained using Tobin's Q.

discussion in Section 4.2). The latter can perhaps be attributed to the conflict of interest between the state and the controlling oligarchs as well as that between the central and the local governments supporting private businesses, thus wiping out any improvement in firm value that would have otherwise taken place. Regarding the impact of the introduction of CG codes in 2004, results from the second part of our analysis suggest that internationally listed Russian firms, which require much higher informational disclosure than for entry onto the Russian Stock Exchange, have significantly higher firm value, though the differential effect of the CG reform of 2004 for internationally listed firms turns out to be insignificant.

Our analysis contributes to a sizeable and growing literature on CG in emerging economies and also the limited literature on tax and CG. In their pioneering article, Schleifer and Vishny (1997) highlighted the beneficial influence of good CG laws on firm performance and value. There is evidence from around the world that firms with better CG practices enjoy a lower cost of capital (La Porta et al., 1998; Ashbaugh-Skaife et al., 2006; Errunza and Mazumdar, 2001; Ashbaugh et al., 2004), lower credit-rate spreads (Yu, 2005) and lower risk (Gompers et al., 2003; Brown and Caylor, 2006). While the earlier literature tends to focus on the ownership and board composition as derived from the agency-cost theory (an ownership and management separation theory explained by Jensen and Meckling, 1976), since the 1990s, the focus has shifted to the legal rules (English common law and French civil law countries) defining creditors' and shareholders' rights. Other studies examine legal enforcement in terms of the rule of law, judicial efficiency and corruption at both country and firm level. Later, Shleifer and Vishny (1997), La Porta et al. (1998) and others found that combining rules relating to ownership and board composition with legal protection for shareholders' rights provides a better understanding of CG practices. More recently, the attention has been shifted to the importance of T&D rules. Patel and Dallas's (2002) study is one of the first studies on T&D, which highlighted that firms with good T&D have lower costs in terms of equity capital. Gompers et al. (2003) included T&D as one of the components of CG rules and found that stronger rights in the USA have led to better firm performance. Similarly, Klapper and Love (2002) and Black et al. (2006) considered T&D parameters along with other CG practices. Other studies used CG indices provided by specialised ranking agencies or constructed their own proxies (see e.g., Black et al., 2000; McKinsey & Company, 2002; and Aggarwal et al., 2007). The general consensus in this literature is that better T&D rules tend to lower the cost of capital, increase firm performance and provide a better understanding of the firm's business environment. This is because better CG resolves the conflict of interest between the controlling and minority owners. Turning now to the limited literature on CG in Russia, we find three recent studies; namely, Black (2001), Goetzmann, Spiegel and Ukhov (2004) and Black, Love and Rachinsky (2006). All these studies tend to focus on a relatively small sample and none of them particularly focused on the period after the introduction of the CG codes in 2002. The most recent of these studies, namely that by Black, Love and Rachinsky (2006), analysed overall governance indices over the years 1999–2004. Thus, the access to the unique S&P data on T&D rules in the post-reform period allows us to update the effect of CG on firm value in Russia. We go beyond this literature, in that in addition to the conflict of interest between controlling and minority owners, our analysis highlights how the introduction of T&D rules may not be an unmixed blessing, especially if it instigates a conflict of interest between the state and the controlling owners as well as between the central and the local governments in a decentralised framework. Further, we conduct a formal impact evaluation analysis of the introduction of Russian CG codes in 2004 by exploiting the differential behaviour of domestic and internationally listed Russian firms in our sample over 2000–2008. There is a suggestion that the international (as opposed to the domestic) listing of Russian firms may improve the value of Russian firms, though the average impact of the CG reform turns out to be insignificant for the period of 2000–2008. Our results also complement the limited literature on tax and CG that argues that a stringent tax-enforcement regime can increase the amount outside shareholders will receive, even accounting for increased levels of taxation (see e.g., Desai, Dyck and Zingales, 2007). Instead, we argue that higher taxes and stringent tax enforcement may generate a conflict of interest not only between the controlling owner and the central government, but also between the central and local governments (supporting private businesses), which may counteract the effectiveness of CG reforms (including the T&D rules).

The chapter is developed as follows. Section 4.2 describes the history of CG in Russia with special reference to the recent CG codes and Section 3 describes the data. Section 4.4 refers to methodology, while Section 4.5 presents and analyses the results. The final Section 4.6 concludes.

4.2. Hypothesis development: The perceived link between CG and firm value may not always hold

CG laws/rules have evolved over centuries, often in response to corporate failures or systemic crises. Many think that inadequate and inconsistent regulation of financial markets caused the first global economic crisis of the 21^{st} century. The inadequate availability of accurate information on risk exposure has further highlighted the crucial importance of risk management and disclosure by financial institutions around the globe. As President Obama said in his inaugural address, "this crisis has reminded us that without a watchful eye, the market can spin out of control." Lax oversight allowed corporations to take on excessive risks, and poor disclosure practices left investors unaware of the dangers lurking in their portfolios.

4.2.1. Background

Russia is a unique case in the context of CG. Barring successful CG systems such as those in the USA, Germany or Japan, legal protection of investors in most countries is rather weak, either because the laws are weak or because the courts do not enforce the laws. As a consequence, most firms remain family controlled and highly concentrated, leading to large-scale expropriation of small investors including minority shareholders and creditors. This results in the serious undervaluation of Russian firms.

The present chapter primarily focuses on one aspect of the CG mechanism in Russia that deals with T&D rules. In our case, T&D is the only available, consistent and up-to-date information for firms in our sample. Russia set good T&D mechanisms in place, essentially to protect the rights of the minority shareholders, creditors and other outsiders who do not have first-hand knowledge about the firm and its prospects, against extraction of private benefits by insiders taking advantage of their superior information.

We focus on the period 2000–2008, which has been a period of rapid political and economic change in Russia when Mr. Putin succeeded Mr. Yeltsin in March 2000. Putin's goal was to reassert Kremlin control over a chaotic, cash-strapped state dominated by big businessmen with a view to replacing the oligarchs of Boris Yeltsin's presidency, who hustled their way to wealth in murky post-Soviet privatisations through his own allies. Under President Yeltsin, high tax rates and low levels of tax enforcement encouraged Russian firms to shelter income aggressively. Multiple taxes from different levels of government meant that tax obligations could exceed profits. Company executives were not shy about how this tax burden affected their behaviour. As Yukos Oil CEO Khodorkovsky argued, “As long as the tax regime is unjust, I will try to find a way around it.”[12] Putin radically strengthened the tax-enforcement regime with no change (at least for the first two years) in tax rates and signalled his intentions to crack down on tax evasion by releasing a memorandum with a list of the worst corporate tax offenders (release date July 28th, 2000).

The result was dramatic. Two Yeltsin allies, Boris Berezovsky and Vladimir Gusinsky, fled abroad in 2000, facing fraud charges after clashing with the president. Mikhail Khodorkovsky, owner of oil giant Yukos, was arrested three years later on fraud charges and his oil company was hit with a $28bn back tax bill. The Yukos case taught Putin’s loyal private businessmen that they held their assets at the Kremlin's pleasure and that they should only become involved in politics at their peril. However, there was still a conflict of interest between the central and local governments. In a decentralised set-up, the local governments tried to attract private businesses to their municipalities by protecting these businesses against paying central taxes. The Kremlin tried to resolve the conflict of interest between the central and the local governments by increasing the extent of fiscal decentralisation that allowed the local governments to retain 100% of local revenue raised from personal income taxes. Some municipalities still tried to protect private enterprises from paying central taxes in lieu of high bribery prices, which is a drag on firm value. Sometimes these excessive interventions both from the central and local governments induced the private businesses to shift part of their output underground, thus adversely affecting the value of the legal entity. The result could be a negative or insignificant (when positive and negative effects outweigh each other) effect of the introduction of CG codes on firm value.

4.2.2. The 2002 Russian corporate governance codes

The Russian CG codes, as with countless similar documents enacted throughout Europe, claim to embody universal values of good corporate behaviour. Russia asked the Coudert Brothers, an American law firm, to prepare the international level of its CG with the cooperation of the European Bank for Reconstruction and Development (EBRD), the OECD, the World Bank and the International Finance Corporation.

Before the CG codes were introduced in 2002, several institutions applied a variety of measures to assess the level of CG in Russia. These assessments created useful baseline measures. The Brunswick Warburg Investment Bank (now as a part of UBS) has rated governance implications since 1999. The Troika Dialog Investment House has been

[12] This quotation is taken from “Oligarch? No, I'm just an oil magnate”, *Observer,* Sunday June 4, 2000.

assessing selected firms since 2000. Two non-profit organisations, Corporate Law and Governance and the Russian Institute of Directors, have measured CG since 2001 and 2004, respectively. The change in the corporate environment brought about by the introduction of the CG codes in 2002 has been facilitated by a set of policies, which necessitates a firm to be open and willing to disclose financial and management information to the general public (see a detailed explanation of various CG sub-policies in Bollard, 2003). A growing body of literature suggests, however, that Russia's national culture and socio-political environment will also significantly influence how the CG system develops (Kakabadse and Kakabadse, 2001).

The CG code has made some progress since its introduction in 2002. Despite all the drawbacks and lack of a necessary business/political environment, the joint venture between the two energy giants TNK and BP demonstrated Russia's emerging openness to foreign investors. Another positive example of CG implementation within energy firms concerns the reorganization of the utility holding company RAO UES. GAZPROM, the second-largest company in 2003 (by capitalised market value) is seen as having huge business potential. Yukos, the largest energy company, has made progress in CG despite (or perhaps leading to) the arrests of several of its executives on charges of tax evasion and economic crimes. Yukos has been releasing financial statements prepared in accordance with US Generally Accepted Accounting Principles (GAAP) since 2001 and was audited by the international accounting firm PriceWaterhouseCooper (PWC) (Yukos website).

Given the availability of the T&D indices for the period 2003–2007, as compiled by S&P, we first consider the sample for 2003–2007. In doing so, we not only distinguish between energy and non-energy sector firms, but also distinguish between utility and oil and gas sector firms within the energy sector with a view to comparing the effect of CG codes across sectors. We also check the robustness of our results in various ways (see the further discussion in Section 4.3). We further extend our analysis to consider the overall effect of the introduction of the CG code in 2002 (which came into effect in 2004) on firm value in our sample for 2000–2008 (which includes the years before and after the official introduction of CG codes). In this case, we are also able to account for the differential effect, if any, of the CG reform for internationally listed Russian firms (relative to those listed domestically). This is motivated by the fact that the international listing of Russian firms required a much greater transparency than is required by the Moscow Stock Exchange and did not coincide with the introduction of CG reform in 2004.

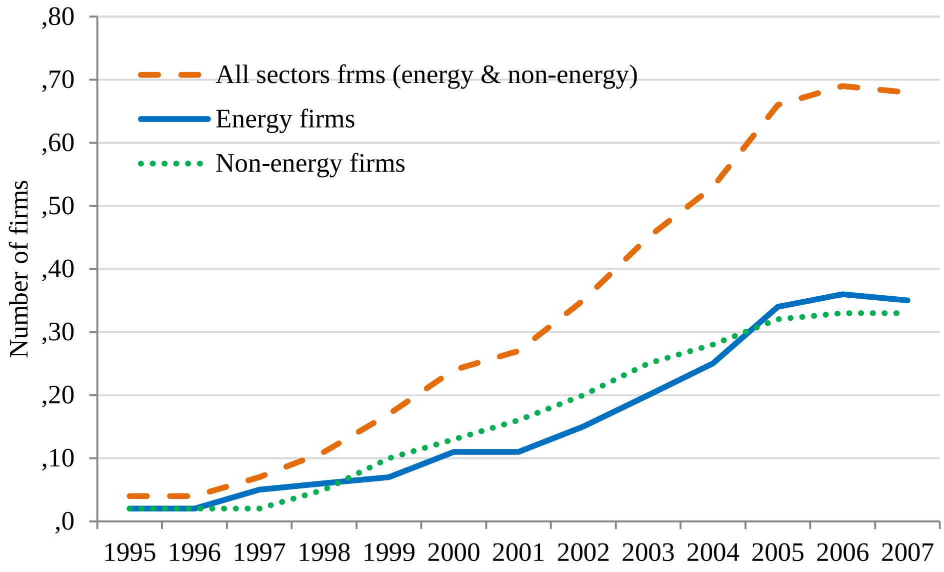
Some Russian companies moved towards greater T&D, providing opportunities for foreign investors to acquire an interest in the company and adopting international management practices such as international accounting standards, listings on international stock exchanges and, thus, improved standards of CG. Despite advances by these few CG adopters, however, Russia is still characterised by a general lack of transparency in a political environment plagued by centralized state bureaucracy, corruption and an inefficient judicial system, where state machinery often preys on private businesses.

4.3. Data and methodology

The data used in this analysis has been obtained primarily from OSIRIS firm-level data for Russian energy companies, which has been widely used in the related academic literature (see e.g., Black, 2001; Klapper and Love, 2002; Goetzmann, Spiegel and Ukhov, 2004; Black et al., 2006; and Black, Love and Rachinsky, 2006). OSIRIS is a fully integrated public listed company database and analytical information solution produced by the Bureau van Dijk, an electronic data publishing company. In this respect, we consider the listed Russian firms from 2000 to 2008, which has been a period of rapid economic recovery and subsequent growth under the leadership of President Putin. OSIRIS data was then merged with the firm-level T&D data obtained from S&P (see Appendix 4.B for further details on the construction of these indices).

We apply GICS 4-digit code to classify firms in our sample. As we focus on the energy industry, GICS allowed us to identify nine main energy subsectors within the energy industry. We have selected utilities and oil and gas producers as the two largest ones consisting of 64% of the overall energy sector. The two largest energy sectors consist of 23 companies. The remaining energy sector companies are labelled as the ‘other energy’ sector (which consists of 13 companies). Figure 4.1 and Appendix 4.C provide some summary statistics for the selected sectors and subsectors. Given that S&P’s T&D indices focus on the largest energy sector firms, we considered the 36 largest firms in 2007. While 181 Russian energy firms are available in the OSIRIS, the 36 within S&P’s database are the largest ones. Further, we distinguish energy sector firms from leading non-energy sectors, which include firms operating in telecommunications, metallurgy, banking, food, consumer and retail markets and IT engineering.

Figure 4.1: Distribution of energy sector firms, 1995–2007



Company data for the analysis has primarily been obtained from OSIRIS firm-level data (1995–2008) based on the companies included in the T&D studies provided by Standard & Poor (2003–2007). As we are interested in the energy sector firms, we separate and define the energy sector firms based on the GICS sectoral description available through OSIRIS. There is a clear pattern of an increased number of companies from 4 in 1995 to 68 being observed in 2007, where energy companies consist of 53% of all firms within the sample.

Russia's stock market is dominated by the natural resource sectors, which comprise about two-thirds of the market (Lazareva et al., 2007). Russia has the largest proven natural gas reserves in the world (1,688 trillion cubic feet) and the seventh-largest proven oil reserves (60.0 billion to 74.4 billion barrels) (BP review, 2007). Europe depends on Russian energy: Russia provides 33.5% of the oil consumed in the EU and 42% of its gas usage (Erixon, 2008). The importance of the energy sector in our study can be further highlighted by the two following observations. First of all, the Russian energy companies are significant because of how much they contribute to the economy. When Russia began implementing its CG mechanism, five energy giants – namely, Yukos, Gazprom, Lukoil, Surgutneftegaz and Sibneft – cumulatively represented 56% of the value of all the stocks listed on the Russian Stock Market: USD 106,408 million out of USD 189,029 million in 2003 (Expert RA, 2004). Foreign investors often considered stock in Russian energy firms to be a key holding in their international portfolios. Furthermore, a comparison of total sales by companies in these two sectors between 2003 and 2007 clearly highlights the importance of energy sector firms in Russia. The percentage of total sales by energy industry varies between 82% and 85% during this period; in other words, only about 15%–18% of total sales pertain to the non-energy sector of the country.

Firm-level balance sheet data from OSIRIS pertains to profit and loss accounts and cash flow statements for all existing firms. Although we use the comprehensive firm-level database to analyse effects within the energy sector, the consistency of information from OSIRIS and S&P allows us to be confident of the descriptive statistics and regression analyses we produce.

4.3.1. Transparency and disclosure indices

We obtained a number of different T&D indices from S&P covering various aspects of corporate financial behaviour. This allows us to assess the predictive power of different measures of T&D. It is important to choose the most acceptable T&D measures. Unlike much of the existing literature, we have access to S&P's T&D indices that have been consistently constructed for the 80 largest listed Russian companies with the most liquid stocks (90% of cumulative market capitalisation of the Russian Stock Market in 2007) over the period from 2003–2007 (S&P's reports, 2003–2007).

A clarification is in order before we begin: while there are more than 300 public companies in Russia, we focus on the largest companies covered by S&P; this sample may not be representative of all Russian companies. As the larger companies tend to be more transparent than the smaller ones, our sampling method is likely to generate an upward bias in assessing transparency of the entire population of public Russian companies. In contrast, since the companies included in this survey account for approximately 90% of the cumulative capitalisation of the Russian Stock Market, they represent the major part of the Russian economy in terms of assets and operations. Subject to these clarifications, we considered the following T&D indices[13]:

- T&D financial and operational information
- T&D ownership structure and shareholders' rights
- T&D board and management structure

[13] S&P applied two criteria to select the companies in the study: size and liquidity. As a rule, the liquidity of stocks positively depends on the size of the company, but there are exceptions, especially in cases of a minor free-float. Each T&D index is based on about 30 survey questions for each of the sections: T&D financial and operational information, T&D ownership structure and shareholders' rights, and T&D board and management structure. These questionnaires were circulated to the top Russian firms from various industries such as telecommunications, energy, manufacturing and advertising. S&P analysis accounts for information included in the three major sources of public information: annual reports, Web-based disclosures and public regulatory reporting. S&P views corporate transparency as an important factor affecting a firm's attractiveness to investors and an important element of corporate governance. The study includes around 80 of the largest Russian stock companies with the most liquid assets. The companies included in the survey account for approximately 90% of the cumulative capitalisation of the Russian Stock Market and they represent the major part of the Russian economy in terms of assets and operations.

We used the T&D overall score, which measures general implementation of the CG code. As defined by S&P, T&D's 'financial & operational' index measures the openness and availability of accounting data, employment standards, consistency with regulations, an explanation and description of the firm and its market position etc. The T&D's 'ownership' index demonstrates the availability of data on the ownership structure. The T&D's 'board & shareholders' index shows the disclosure of the management structure. S&P measures the T&D score in percentages with a maximum of 100%; a higher score means better T&D within the company. The same T&D indices, but for a shorter period of time, were used by Black, Love and Rachinsky (2006).

Our research not only covered the energy sector, but was also extended to non-energy sector firms covering telecommunications, retail, communications, and real estate among others. Our results clearly show that the energy industry generally underperformed relative to the non-energy related sectors (see Figure 4.2 and Table 4.1). Despite its lower performance initially, the T&D overall index for the energy sector corporations subsequently increased so that the energy sector firms are now in line with the other industries.

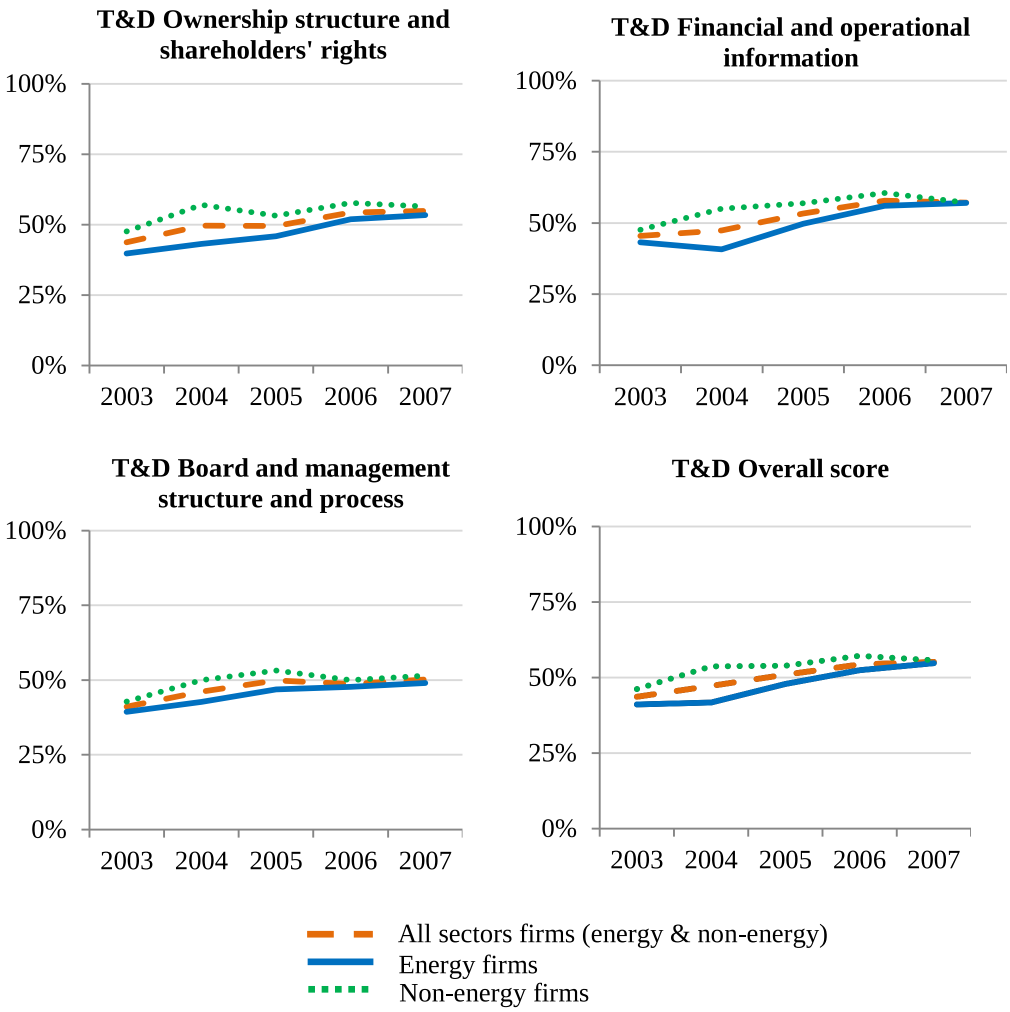
Table 4.1: Means and standard deviations of selected T&D indexes, 2003–2007

Variable	**All industries**		**Non-energy sector**		**Energy sector**		**Oil and gas producers**		**Utilities**	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
T&D overall	0.52	0.16	0.54	0.17	0.50	0.15	0.50	0.17	0.46	0.12
T&D financial & operational	0.54	0.18	0.56	0.18	0.52	0.18	0.53	0.20	0.44	0.15
T&D ownership	0.52	0.18	0.55	0.20	0.49	0.16	0.47	0.19	0.47	0.12
T&D board & shareholders	0.48	0.16	0.50	0.18	0.46	0.14	0.44	0.16	0.47	0.13

The four T&D indexes that are described and presented in Figure 4.2. That is, there are four transparency & disclosure (T&D) indexes as proxies of corporate governance (CG) provided by Standard & Poor's year-to-year studies from 2003–2007. T&D overall measures the general implementation of the CG code, T&D financial & operational information defines openness and availability of accounting data, employed standards, consistency with regulations, an explanation and description of the firm and its market position etc. T&D ownership demonstrates the data availability on the ownership structure. T&D board & shareholders shows the disclosure of the management structure. T&D is measured in percentages with a maximum of 100% where a higher score means better T&D within a company.

Next, we considered the trend in T&D indices over the sample years, as shown in Figure 4.2. It follows that the energy sector's T&D overall index increased from 40% in the first two years after the CG policy implementation to around 55% in 2007, which moves into line with the average level for the country as a whole. Although the non-energy companies started at a higher level of T&D than the energy companies in 2003, by 2007 they were at the same level as energy companies, indicating that overall transparency increased faster for firms in the energy sector. Similar observations are noted when we consider individual T&D indices: the progress was faster in the energy sector. Black, Love and Rachinsky (2006) made similar observations for the period 1999-2004. Figure 4.2 summarises the change in various T&D measures and also the composite T&D measure over 2003-2007, which highlights a growing trend of firm-level transparency on all accounts in our sample.

Figure 4.2: T&D indexes, 2003–2007



There are four transparency & disclosure (T&D) indexes as proxies of corporate governance (CG) provided by Standard & Poor's year-to-year studies from 2003–2007. T&D overall measures the general implementation of the CG code, T&D financial & operational information defines openness and availability of accounting data, employed standards, consistency with regulations, an explanation and description of the firm and its market position etc. T&D ownership demonstrates the data availability on the ownership structure. T&D board & shareholders shows the disclosure of the management structure. T&D is measured in percentages with a maximum of 100% where a higher score means better T&D within a company. The same T&D indexes, but over a shorter period of time, were examined by Black et al. (2006).

4.3.1. Control groups: Internationally versus domestic listed companies

Although all sample firms were listed on the stock exchange, it is important for us to find out if some firms were listed on any international stock exchanges; the latter may sometimes be labelled as cross-listing, as these firms were not only listed on the Russian Stock Exchange, but also on some other foreign stock exchanges. This is particularly important for the post-2000 period, which was the period of economic recovery that subsequently gave rise to rapid economic growth in Russia.

During this period, many of the largest Russian firms went into listing on foreign stock exchanges (often on the London Stock Exchange). While we can extract information from OSIRIS as to whether a firm was listed on the international stock exchange in the latest year of the survey, unfortunately, this information was not available for the other years from 2000 and 2007.

However, given that a listing is relatively time invariant, we use this 2008 information to assess if internationally listed Russian firms behave differently from other domestically listed firms (see the further discussion in Section 4.4.2) because they were subject to more stringent international CG codes. In other words, we consider domestically listed Russian firms as the treatment group, as they were primarily guided by the Russian CG codes introduced in 2002 that came into effect from 2004 onwards. In contrast, internationally listed Russian firms constitute the control groups, as they are guided by different international rules.

4.3.2. Firm value as a Tobin's Q measure

Tobin's Q is a widely used measure of firm value in the literature (e.g., Mueller & Reardon 1993; Blanchard et al., 1993; Denis and McConnell, 2003 and La Porta et al., 2002). In our study, we constructed two alternative measures of Tobin's Q:

- firm market capitalisation divided by total assets
- firm market capitalisation plus total debt divided by total assets[14]

Table 4.2 and Figure 4.3 show the descriptive statistics for the firm value in our sample. Note that the average value of Tobin's Q varies between 0.87 and 2.27, depending on the particular definition of the variable and also on the sector in which they were operating. Researchers have suggested that the largest Russian companies find themselves overvalued, since the market value of a company is greater than the recorded assets (e.g.,

[14] We also tried other profitability parameters such as return on assets and earnings before interest and taxes divided by total assets, but were unable to find any significant evidence with these alternative measures.

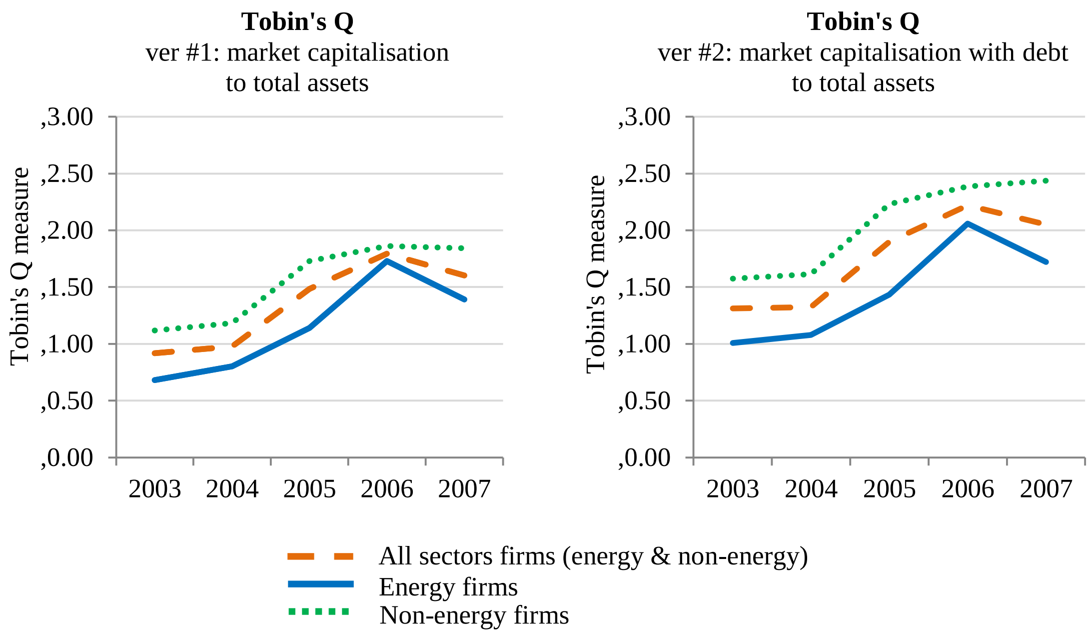
Tobin and Brainard, 1977). In our investigation, utility firms have the smallest value index, at approximately 1.00, which still points towards overvaluation.

Table 4.2: Means and standard deviations of selected Tobin's Q, 2003–2007

Variable	**All industries**		**Non-energy sector**		**Energy sector**		**Oil and gas producers**		**Utilities**	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Tobin's Q #1 ver.	1.17	1.35	1.31	1.73	1.03	0.78	1.11	0.75	0.87	0.85
Tobin's Q #2 ver.	1.61	1.32	1.87	1.66	1.36	0.79	1.44	0.75	1.15	0.87

The firm's value as defined through two Tobin's Q alternative ratios and as presented over time in Figure 4.3. The first ratio is the company's market capitalisation to total assets and the second proxy is defined as a firm's market capitalisation including total debt to total assets ratio. The Tobin's Q, in general, measures the firm's investment to its cost of capital and was first employed by Mueller and Reardon (1993).

Figure 4.3: Firm value, 2003–2007



The firm's value defined through two Tobin's Q alternative ratios. The first ratio is the company's market capitalisation to total assets and the second proxy is defined as a firm's market capitalisation including total debt to total assets ratio. The Tobin's Q, in general, measures the firm's investment to its cost of capital and was first employed by Mueller and Reardon (1993).

4.3.3. Additional firm-level measures

In order to identify the effect of T&D on Tobin's Q, we controlled for additional firm-level characteristics, which are likely to influence firm value. These control variables include firm age, the Herfindahl index of market concentration, company size (as the natural logarithm of total assets) and leverage (the ratio of total liabilities to total assets). Choice of these variables is guided by the literature, for example, Franks and Mayer (2002), Rajan and Zingales (1995), Booth et al. (2001), de Haas and Peters (2004), Cole (2008) and Driffield and Pal (2010).

We measured market concentration using the Herfindahl index, named after its original proponent, Herfindahl (1950). Essentially, the Herfindahl index measures how concentrated the industry is; how many competitors in a sector results in a lower concentration, while fewer competitors increases the level of concentration. As a rule of thumb, a Herfindahl index below 0.10 signals a low concentration or an unconcentrated market, while a Herfindahl index above 0.18 signals a high concentration. An index falling between 0.10 and 0.18 indicates that the industry is moderately concentrated[15]. Table 4.3 shows that the average Herfindahl index is high for all the sectors considered in our analysis, implying a monopolistic market environment in Russia.

Table 4.3: Means and standard deviations of selected additional variables, 2003–2007

Variable	**All industries**		**Non-energy sector**		**Energy sector**		**Oil and gas producers**		**Utilities**	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Firm concentration										
Herfindalh index	261	303	315	367	282	312	301	298	529	452
Firm size, leverage, age										
Ln of total assets	14.31	1.79	13.80	1.65	14.84	1.77	15.47	1.98	14.12	1.57
Liabilities to assets	0.45	0.23	0.53	0.22	0.37	0.21	0.36	0.19	0.33	0.19
Firm age	17.53	26.43	16.66	24.16	18.53	28.82	4.89	4.54	27.96	43.86

We include widely used additional explanatory variables as firm size denoted through the natural log of total assets, the leverage level as total liabilities to total assets ratio and firm age (e.g. Rajan and Zingales, 1995; De Haas and Peters, 2004; Cole, 2008; Driffield and Pal, 2010).

We also included how long the firm had been in existence. In general, Table 1 demonstrates that the average age of all the firms in our study is 20 years. The most recently established firms in the oil and gas production sector average 7 years old; the oldest companies in the utilities sector average 30 years old. The average ratio of total

[15] In our analysis, we have multiplied the Herfindahl index by 100 in order to standardize the variable. The U.S. Department of Justice and the Federal Trade Commission in the 'Horizontal Merger Guidelines' apply a Herfindahl indexation up to 100^2 or in the 10,000s. (http://www.justice.gov/atr/public/guidelines/hmg.htm#N_17_).

liabilities to total assets is approximately 0.45. It follows that, compared to utilities, firms in the oil and gas subsector are not only larger on average, but are also more leveraged.

4.4. Methodology

4.4.1. Panel estimates of firm value, 2003–2007

To start with, we employ a pooled panel data model using OLS. Our sample consists of unbalanced panel data arranged for a group of firms observed over the years 2003–2007. Choice of the sample period is guided by the fact that the T&D indices are available only for 2003–2007. The measure of firm value is Tobin's Q. In addition, we implement a control for other possible covariates; namely, firm size, age and the Herfindahl index.

The detailed estimation procedure is described in Chapter 2. Hence, we start estimation with the pooled OLS. However, each observed firm may have its own individual characteristics, which may or may not influence the regression results. Therefore, we estimate with various panel data specifications such as OLS-RE, OLS-FE, OLS-FD, a discussion on elasticities and the GMM estimator to control for the inclusion for the lagged dependent among the regressors. In regards to the GMM estimator, following Arellano and Bond (1991), the lagged dependent variable is treated as endogenous, and the independent variables are treated as strictly exogenous (T&D, size, age, Herfindahl index and leverage measure). In this instance, the GMM estimator used the second lag of the endogenous variable. Additionally, we utilize only internal instruments and, hence, no additional external instruments are included. In each of the panel estimation specifications, we control for heteroscedasticity (White's standard errors' implementation). We apply post-estimation tests for the statistical validity of the findings following the theoretical background from Chapter 2. Our empirical analysis focuses on the size, sign and significance of the estimated coefficients and the elasticity. That is, the general equation of the firm value of the i-th firm in year t is given by:

$$Q_{it} = \gamma_1 Q_{it-1} + \beta_1 T\&D_{it} + \beta_2 Size_{it} + \beta_3 Age_{it} + \beta_4 Herfindahl_{it} + \beta_5 Leverage_{it} + \alpha_i + u_{it} \qquad \text{Eq. (4.1)}$$

where

Q_{it} = Tobin's Q of the i-th firm in the t-th year,

t = 2003–2007,

γ and β = coefficients of the variables,

α_i = firm-specific unobserved factor,

u_{it}= firm (i) and year (t) specific error term.

At first, to test that T&D indexes influence firm value, we start with Eq. (3.1) by including the overall index (Tables 4.4 and 4.6). In order to test specific T&D proxies, we estimate various T&Ds and demonstrate the effect of T&D financial and operational information, as the results for two additional T&D measures are insignificant (Tables 4.7 and 4.8). In doing so, we present results for all industries, for both the energy and non-energy sector, as well as for two major subsectors: utilities and oil and gas producers. This industry and sectoral segmentation allows us to see if the potential of T&D specification may impact differently on the company valuation among the companies.

Further, there is a fair possibility that in addition to T&D, there is a set of control variables that could result in diverse patterns in the relationship between T&D and Tobin's Q. For this reason, we introduce control measures, which are commonly used in relation to firm valuation, as described in Section 4.2. In addition, the control for the previous period of T&D activity has been implemented by inclusion of the lagged dependent among the regressors yielding the GMM estimator.

4.4.2. Panel estimates of firm value: CG and stock-market allocations

Although we do not have access to any T&D indices for the period before 2003, (T&D information is available only for 2003–2007), we generate a binary variable indicating the introduction of CG rules in the country. Recalling that Russia introduced the CG mechanism in 2002, the first reporting year under these new rules was 2003, for which the financial reports did not become available until 2004. Accordingly, we constructed a dummy variable CG2004 that takes a value of 1 for the year 2004 and beyond and zero for the years before 2004. The rationale for doing this is to exploit the exogenous introduction of CG reform as an instrument for T&D rules in our sample. Impact assessment also necessitated the identification of a control group of firms who were not necessarily affected by the introduction of the CG codes in 2004. As a result, we are also able to consider the larger sample of 2000–2008 in this case. Given that many Russian firms became internationally listed post-2000, a period of rapid economic recovery and subsequent growth in Russia, we treat these firms as our control (untreated by the CG codes) group. Accordingly, we create a second binary variable LI that takes a value of 1 if a sample firm was listed during 2000–2008 and 0 otherwise. Internationally listed Russian firms were subject to more stringent CG rules and, as such, we can exploit this variation across domestically and internationally listed firms to identify the differential effect of CG reform, if any, on internationally listed firms (this is captured by the inclusion of the interaction between CG2004 and LI). Accordingly, we specify a model determining Tobin's Q of the i-th firm as follows:

$$Q_{it} = \gamma_1 Q_{it-1} + \beta_1 CG2004 + \beta_2 LI + \beta_3 (CG2004*LI) + \beta_4 Size_{it} + \beta_5 Age_{it} + \beta_6 Herfindahl_{it} + \\ + \beta_7 Leverage_{it} + \alpha_i + u_{it} \qquad \text{Eq. (4.2)}$$

where

Q_{it} = Tobin's Q of the i-th firm in the t-th year,

t = 2003–2007,

γ and β = coefficients of the variables,

α_i = firm-specific unobserved factor,

u_{it}= firm (i) and year (t) specific error term.

As before, we included other covariates, which consist of firm size, age, the Herfindahl index and leverage to identify the effect of overall CG mechanism implementation on Tobin's Q (Table 4.9). The sector control would capture the effects of the unobserved sector level factors including taxes, tax enforcement and/or any shocks.

Ceteris paribus, the estimated coefficient of the period dummy CG2004 would highlight the effect of the introduction of CG codes on firm value for all sample firms. Note, however, that the CG2004 dummy incorporates the overall effect of all CG reform and not just the effect of the T&D rules that we considered in Section 4.1. The estimated coefficient of LI (internationally listed Russian firms) would, however, highlight the effect of an international listing LI on Tobin's Q in our sample. The variable of particular interest to us is β_2LI, which is the interaction term between LI and CG2004. The estimated coefficient of the interaction term would allow us to identify the differential effect of the introduction of the CG code on internationally listed firms, if any. This is the essential coefficient that determines the mean impact of the introduction of the CG code in our sample.

4.5. Results

This section presents and analyses the estimates. Section 4.5.1 discusses the estimates of Eq. (4.1) for the utilities and oil and gas subsectors within the energy sector and also compares the estimates for the overall energy sector firms with other non-energy sector firms. Section 4.5.2 presents and analyses the estimates of Eq. (4.2) for the period of 2000–2008. Appendix 4.A provides detailed tables for the alternative Tobin's Q definition and T&D indices' estimates for the non-energy sector.

4.5.1. Panel estimates of firm value, 2003–2007

Our results on the T&D impact on firm value suggest that the estimated coefficients of the particular T&D index are not only significant for the whole sector taken together, but also for the energy industry (utilities and the oil and gas sectors) pooled together. After controlling for all other factors, the significant positive effect of T&D rules appears when considering composite T&D and T&D financial and operational information availability. These findings support John and Senbet (1998), Errunza and Mazumdar (2001), Roberts (2004) and Yeoh (2007), who argued that recognised accounting and corporate integrity within companies can stimulate investment incentives and, in the end, financial markets, thus explaining higher firm value. If, however, we compare the estimates between the two major energy subsectors – utilities and oil and gas producers – the T&D effect is significant only for utilities. It thus appears that the estimate for the overall energy sector has been driven by the utilities (note that results for an alternative Tobin's Q measure provide similar significant results with all industries and the energy sector as the main proxy, and are presented in Appendix 4.A). A possible explanation for the lack of significance of T&D in the oil and gas sector may arise from the conflict of interest between the controlling owner and the state as well as from the conflict between the central and state governments. As indicated earlier, this is a sector dominated by the five energy giants comprising approximately 56% of the total market capital of the Moscow Stock Exchange. Evidently, these energy firms are significantly larger than other non-energy sector firms, and, as such, may be subject to greater predatory behaviour of the state, thus giving rise to a conflict of interest between the controlling owners and the state, which may counteract the purpose of introducing T&D rules. Accordingly, the energy giants may have greater risks when under the prying eyes of state agencies, especially when the new CG code requires them to be transparent. This is because greater transparency may make them more vulnerable to higher taxes by the state agencies (the recent high profile case of

Mikhail Khodorkovsky of Yukos is a pointer to this argument). Thus, the conflict of interest between the controlling owner and the state may harm firm value in the oil and gas sector in various ways; it may be attributable to the high bribery costs paid by these large companies to shelter high revenue and/or in transferring part of the output underground to avoid tax intervention by the government (Triesman, 2000).

Table 4.4: Estimates of Tobin's Q:
T&D overall for all industries and the energy sector, 2003–2007

	Pooled OLS 1	OLS-RE 2	OLS-FE 3	First difference (robust clustered) 4	GMM (inclusion of lagged dependent) 5
A. All industries (energy and non-energy)					
T&D overall	1.273	**1.273***	**1.323***	**2.247****	**0.7480***
	(1.001)	(0.719)	(0.792)	(0.876)	(0.499)
Herfindalh index	**-0.0143****	**-0.0143***	0.0202	0.0159	**0.0302*****
	(0.00638)	(0.00861)	(0.0145)	(0.0118)	(0.00992)
Total assets	**-0.358****	**-0.358*****	**-0.674****	0.0251	**-0.105****
	(0.152)	(0.124)	(0.274)	(0.331)	(0.0493)
Liabilities to total assets	-0.773	-0.773	-0.612	-0.212	**-1.026****
	(0.602)	(0.667)	(0.809)	(1.015)	(0.423)
Firm age	-0.00201	-0.00201	**0.265*****		0.00110
	(0.00498)	(0.00804)	(0.0967)		(0.00240)
Lag of dependent Tobin's Q					**0.302*****
					(0.0858)
Constant	**7.494*****	**7.494*****	3.529	0.0732	0.219
	(2.366)	(2.020)	(3.802)	(0.118)	(1.211)
Observations	137	137	137	83	138
Number of companies	52	52	52	36	52
Joint test	0.0199	0.0147	0.0210	0.0755	0.0000
Hausman test			0.0268		
Weak instruments					0.0001
B. Energy industry					
T&D overall	1.311	**1.311***	**1.328***	**2.257****	**0.5710***
	(1.005)	(0.720)	(0.795)	(0.879)	(0.503)
Herfindalh index	**-0.00984***	-0.00984	0.0127	0.00951	**0.0201*****
	(0.00503)	(0.00656)	(0.00999)	(0.00793)	(0.00769)
Total assets	**-0.350****	**-0.350*****	**-0.668****	0.0334	**-0.111****
	(0.152)	(0.124)	(0.275)	(0.332)	(0.0496)
Liabilities to total assets	-0.757	-0.757	-0.612	-0.221	**-1.056****
	(0.600)	(0.668)	(0.811)	(1.018)	(0.426)
Firm age	-0.00185	-0.00185	**0.242*****		0.00104
	(0.00496)	(0.00806)	(0.0887)		(0.00242)
Lag of dependent Tobin's Q					**0.288*****
					(0.0864)
Constant	**7.215*****	**7.215*****	4.259	0.0485	0.703
	(2.345)	(1.990)	(3.615)	(0.112)	(1.188)
Observations	137	137	137	83	138
Number of companies	52	52	52	36	52
Joint test	0.0419	0.0185	0.0240	0.0898	0.0000
Hausman test			0.0227		
Weak instruments					0.0030

Note: White's standard errors were applied to control for heteroscedasticity

This table demonstrates the main target we would like to assess, which is the implication of T&D overall implementation for firm value, with control for explanatory measures. The regression results are based on various panel data specifications, which are presented in detail, and with an alternative Tobin's Q proxy in Appendix 4.A. The theoretical methodology was discussed in Chapter 2. The main dependent variable is defined as 'firm market capitalisation divided by total assets'. Dependent variable and explanatory measures definitions are presented in related sections. The joint test, years test and weak tests are presented as 'Prob>F'. Legends (*) to the right of the coefficients, denoting the significance levels (* $p<0.1$; ** $p<0.05$; *** $p<0.01$).

While the positive T&D effect for all firms in our sample tends to be in line with the existing literature concerning Russian corporations (see e.g., Black, 2001; Goetzmann, Spiegel and Ukhov, 2004; Black, Love and Rachinsky, 2006), we believe that the identification of the potential negative effect of the introduction of T&D rules, which may render the total effect to be insignificant, as in the case of the Russian oil and gas sector, is a novel contribution of our analysis and we attribute this to the predatory behaviour of the state.

Among other results, our research shows that a firm's size (measured by total assets) and leverage (calculated as the ratio of liabilities to assets) both tend to lower firm value, irrespective of the Tobin's Q measure chosen. In contrast, firm value is significantly better for older firms. There is also a significant negative relationship between the Herfindahl index of market concentration and firm value for firms in the oil and gas production sector and for all non-energy industries. The negative effect in non-energy firms is almost three times as large compared to the oil and gas companies.

Furthermore, the results on the elasticity define the percentage change in the firm value for a 1% change in the explanatory variables. The advantage of elasticity over the coefficient estimates (i.e. in Table 4.4) is that it measures the proportionate terms between the two measures (Wang and Jain, 2003). Following Table 4.5, the market concentration (Herfindalh index) and the company size are considered to be elastic in terms of a firm's value (i.e. the size of the elasticity is greater than 1). That means that the market concentration and the firm size tend not to be the most important measures when assessing company value, although they remain statistically significant. On the other hand, the T&D index, company liabilities, firm age and previous year firm value are inelastic (less than 1), meaning that these things are more important to the Tobin's Q calculation.

Following the theoretical background description in Chapter 2, the panel data estimation, including control for heteroscedasticity and the reported post-estimation tests, suggests that the given results are valid. The reported statistics for the joined significance of the included explanatory variables suggest that these are jointly significant and, hence, should be included. The years test indicates that the year's coefficients are jointly equal to zero and thus controlling for the specific time occurrences is important. Further, the Hausman test indicates that fixed effects should be preferred in the OLS specification, allowing for the control of the correlation between the individual and/or time effects and the independent variables. In regards to the dynamic panel specification (GMM), the weak instruments control for a potential of selecting the "weak" instruments that are poor predictors of the endogenous predictor in the first-stage equation. We do not include additional external instruments and, therefore, the Sargan test is not reported. We may experiment with the external instruments, but because of too many alternatives, the future analysis is aimed to focus on this particular issue.

Note, however, that the introduction of T&D rules is only one aspect of overall CG reform in Russia and, hence, we next consider the effect of the overall CG reform on firm value in Russia. In doing so, we also consider the larger sample of listed firms available from OSIRIS in Section 4.2. In a sense, this additional exercise would allow us to test the robustness of our results pertaining to the introduction of T&D rules.

Table 4.5: Estimates of Tobin's Q: As elasticity
T&D overall for all industries and the energy sector, 2003–2007

	Pooled OLS 1	OLS-RE 2	OLS-FE 3	First difference (robust clustered) 4	GMM (inclusion of lagged dependent) 5
A. All industries (energy and non-energy)					
T&D overall	0.57	0.57	0.59	1.00	0.33
Herfindalh index	-3.19	-3.19	4.51	3.55	6.74
Total assets	-4.38	-4.38	-8.24	0.307	-1.28
Liabilities to total assets	-0.30	-0.30	-0.24	-0.082	-0.39
Firm age	-0.03	-0.03	3.97		0.02
Lag of dependent Tobin's Q					0.30
B. Energy industry					
T&D overall	0.64	0.64	0.64	1.10	0.28
Herfindalh index	-2.69	-2.69	3.48	2.60	5.50
Total assets	-5.04	-5.04	-9.62	0.481	-1.60
Liabilities to total assets	-0.27	-0.27	-0.22	-0.079	-0.38
Firm age	-0.03	-0.03	4.35		0.02
Lag of dependent Tobin's Q					0.29

This table continues on from Table 4.4 by presenting the elasticity for the energy sector and two subsectors. The elasticity defines the percentage change in the dependent variable for a one per cent change in the explanatory variable. The mathematical presentation is 'Elasticity = Estimated explanatory coefficient * (Mean explanatory measure/Mean dependent measure)'. Chapter 2 provides a detailed explanation on elasticity. For instance, in the GMM application for all industries, the 'T&D overall' elasticity of 0.33 means that, on average, for a 1% increase in the T&D index, the firm value would increase by 0.33%. (Elasticity = 0.7480*(0.52/1.17) = 0.33, where the explanatory coefficient is from Table 4.4, and the mean measures are from Tables 4.1 and Table 4.2.)

Table 4.6: Estimates of Tobin's Q: T&D overall for utilities and oil and gas producers, 2003–2007

	Pooled OLS 1	OLS-RE 2	OLS-FE 3	First difference (robust clustered) 4	GMM (inclusion of lagged dependent) 5
A. Utilities					
T&D overall	1.126	1.126	1.274	**2.426*** **	**0.7733***
	(0.978)	(0.714)	(0.788)	(0.856)	(0.480)
Herfindalh index	**-0.00152*** **	**-0.00152** **	0.00266	**0.00262***	**0.00283*** **
	(0.000478)	(0.000655)	(0.00180)	(0.00153)	(0.000704)
Total assets	**-0.387** **	**-0.387*** **	**-0.683** **	0.0574	**-0.0855***
	(0.152)	(0.124)	(0.274)	(0.331)	(0.0480)
Liabilities to total assets	-0.824	-0.824	-0.674	-0.272	**-0.879** **
	(0.616)	(0.659)	(0.804)	(1.026)	(0.411)
Firm age	-0.00263	-0.00263	**0.362** **		0.00121
	(0.00509)	(0.00796)	(0.148)		(0.00233)
Lag of dependent Tobin's Q					**0.360*** **
					(0.0832)
Constant	**7.817*** **	**7.817*** **	1.608	0.174	0.401
	(2.326)	(1.908)	(4.558)	(0.168)	(0.990)
Observations	137	137	137	83	138
Number of companies	52	52	52	36	52
Joint test	0.0014	0.0045	0.0190	0.0183	0.0001
Hausman test			0.0161		
Weak instruments					0.0000
B. Oil and gas producers					
T&D overall	0.708	0.708	0.771	**2.025** **	**0.3180** **
	(0.920)	(0.701)	(0.790)	(0.865)	(0.495)
Herfindalh index	**-0.0125*** **	**-0.0125*** **	**-0.0247** **	**-0.0201** **	**-0.0132*** **
	(0.00258)	(0.00332)	(0.0102)	(0.00888)	(0.00367)
Total assets	**-0.434*** **	**-0.434*** **	**-0.526***	0.204	-0.0767
	(0.148)	(0.123)	(0.267)	(0.322)	(0.0500)
Liabilities to total assets	-0.943	-0.943	-0.821	-0.339	**-0.768***
	(0.634)	(0.638)	(0.786)	(1.018)	(0.430)
Firm age	-0.00397	-0.00397	-0.189		0.00119
	(0.00553)	(0.00791)	(0.157)		(0.00240)
Lag of dependent Tobin's Q					**0.380*** **
					(0.0864)
Constant	**9.640*** **	**9.640*** **	**16.46*** **	**-0.269***	-0.00245
	(2.319)	(1.952)	(5.122)	(0.146)	(1.132)
Observations	137	137	137	83	138
Number of companies	52	52	52	36	52
Joint test	0.0000	0.0001	0.0043	0.0042	0.0000
Hausman test			0.0077		
Weak instruments					0.0000

Note: White's standard errors are applied to control for heteroscedasticity.

This table is a continuation of Table 4.4 but demonstrates the implication of T&D overall implementation for firm value, controlling for explanatory measures for the two main subsectors: utilities and oil and gas producers. The regression results based on various panel data specifications, which are presented in detail in the theoretical methodology discussed in Chapter 2. The main dependent is defined as 'firm market capitalisation divided by total assets'. Dependent and explanatory definitions are presented in related sections. The joint test, years test and weak tests are presented as 'Prob>F'. Legends (*) to the right of the coefficients and denote the significance levels (* p<0.1; ** p<0.05; *** p<0.01).

Table 4.7: Estimates of Tobin's Q: T&D financial and operational information for all industries and the energy industry, 2003–2007

	Pooled OLS 1	OLS-RE 2	OLS-FE 3	First difference (robust clustered) 4	GMM (inclusion of lagged dependent) 5
A. All industries					
T&D fin. & oper.	1.233	**1.233****	**1.176****	**1.593****	0.0580
	(0.809)	(0.541)	(0.575)	(0.660)	(0.441)
Herfindalh index	**-0.0149*****	**-0.0149***	0.0184	0.0132	**0.0300*****
	(0.00578)	(0.00832)	(0.0143)	(0.0118)	(0.00989)
Total assets	**-0.359****	**-0.359*****	**-0.670****	-0.0114	**-0.3100****
	(0.152)	(0.123)	(0.270)	(0.336)	(0.0497)
Liabilities to total assets	-0.820	-0.820	-0.735	-0.488	**-0.989****
	(0.601)	(0.662)	(0.799)	(1.025)	(0.406)
Firm age	-0.00222	-0.00222	**0.260*****		0.00108
	(0.00496)	(0.00802)	(0.0960)		(0.00241)
Lag of dependent Tobin's Q					**0.310*****
					(0.0857)
Constant	**7.568*****	**7.568*****	3.820	0.0824	0.180
	(2.450)	(2.002)	(3.779)	(0.119)	(1.205)
Observations	137	137	137	83	138
Number of companies	52	52	52	36	52
Joint test	0.0204	0.0060	0.0120	0.1030	0.0300
Hausman test			0.0364		
Weak instruments					0.0002
B. Energy industry					
T&D fin. & oper.	1.251	**1.251****	**1.189****	**1.612****	0.0446
	(0.811)	(0.542)	(0.576)	(0.661)	(0.444)
Herfindalh index	**-0.0103****	-0.0103	0.0116	0.00781	**0.0200****
	(0.00456)	(0.00635)	(0.00984)	(0.00793)	(0.00767)
Total assets	**-0.350****	**-0.350*****	**-0.666****	-0.00608	**-0.108****
	(0.152)	(0.123)	(0.270)	(0.337)	(0.0499)
Liabilities to total assets	-0.804	-0.804	-0.734	-0.499	**-1.024****
	(0.599)	(0.664)	(0.801)	(1.026)	(0.408)
Firm age	-0.00206	-0.00206	**0.239*****		0.00101
	(0.00494)	(0.00804)	(0.0879)		(0.00242)
Lag of dependent Tobin's Q					**0.296*****
					(0.0863)
Constant	**7.281*****	**7.281*****	4.477	0.0616	0.663
	(2.425)	(1.974)	(3.587)	(0.112)	(1.183)
Observations	137	137	137	83	138
Number of companies	52	52	52	36	52
Joint test	0.0434	0.0079	0.0134	0.1160	0.0000
Hausman test			0.0274		
Weak instruments					0.0000

Note: White's standard errors are applied to control for heteroscedasticity.

This table is a continuation of Table 4.4 but demonstrates the implication of T&D financial and operational information implementation for firm value. The regression results are based on various panel data specifications which are presented in detail in the theoretical methodology discussed in Chapter 2. The main dependent is defined as 'firm market capitalisation divided by total assets'. The dependent and explanatory definitions are presented in the relevant sections. The joint test, years test and weak tests are presented as 'Prob>F'. Legends (*) to the right of the coefficients and denote the significance levels (* p<0.1; ** p<0.05; *** p<0.01).

Table 4.8: Estimates of Tobin's Q: T&D financial and operational information for utilities and oil and gas producers, 2003–2007

	Pooled OLS 1	OLS-RE 2	OLS-FE 3	First Difference (robust clustered) 4	GMM (inclusion of lagged dependent) 5
A. Utilities					
T&D fin. & oper.	1.157	**1.157****	**1.126***	**1.621****	0.0507
	(0.798)	(0.536)	(0.575)	(0.653)	(0.425)
Herfindalh index	**-0.00154*****	**-0.00154****	0.00235	0.00217	**0.00283*****
	(0.000440)	(0.000632)	(0.00178)	(0.00157)	(0.000703)
Total assets	**-0.391****	**-0.391*****	**-0.676****	0.00692	**-0.0832***
	(0.152)	(0.123)	(0.270)	(0.336)	(0.0484)
Liabilities to total assets	-0.868	-0.868	-0.788	-0.535	**-0.842****
	(0.614)	(0.654)	(0.795)	(1.032)	(0.395)
Firm age	-0.00284	-0.00284	**0.342****		0.00119
	(0.00505)	(0.00793)	(0.148)		(0.00233)
Lag of dependent Tobin's Q					**0.367*****
					(0.0834)
Constant	**7.865*****	**7.865*****	2.199	0.171	0.354
	(2.400)	(1.893)	(4.550)	(0.169)	(0.986)
Observations	137	137	137	83	138
Number of companies	52	52	52	36	52
Joint test	0.0013	0.0017	0.0116	0.0445	0.0000
Hausman test			0.0443		
Weak instruments					0.0000
B. Oil and gas producers					
T&D fin. & oper.	0.835	0.835	0.820	**1.333****	**0.8065****
	(0.782)	(0.531)	(0.581)	(0.670)	(0.438)
Herfindalh index	**-0.0121*****	**-0.0121*****	**-0.0233****	**-0.0194****	**0.0133*****
	(0.00245)	(0.00324)	(0.0102)	(0.00922)	(0.00367)
Total assets	**-0.437*****	**-0.437*****	**-0.540****	0.150	-0.0766
	(0.146)	(0.122)	(0.264)	(0.329)	(0.0503)
Liabilities to total assets	-0.967	-0.967	-0.884	-0.540	**-0.756***
	(0.627)	(0.635)	(0.778)	(1.022)	(0.414)
Firm age	-0.00405	-0.00405	-0.169		0.00118
	(0.00550)	(0.00789)	(0.157)		(0.00241)
Lag of dependent Tobin's Q					**0.382*****
					(0.0867)
Constant	**9.556*****	**9.556*****	**16.00*****	-0.234	-0.0584
	(2.348)	(1.941)	(5.109)	(0.148)	(1.126)
Observations	137	137	137	83	138
Number of companies	52	52	52	36	52
Joint test	0.0000	0.0000	0.0028	0.0092	0.0001
Hausman test			0.0077		
Weak instruments					0.0000

Note: White's standard errors are applied to control for heteroscedasticity.

This table is a continuation of Table 4.4 but demonstrates the implication of T&D financial and operational information implementation for firm value, controlling for the explanatory measures for the two main subsectors: utilities and oil and gas producers. The regression results are based on various panel data specifications, which are presented in detail within the theoretical methodology section discussed in Chapter 2. The main dependent is defined as 'firm market capitalisation divided by total assets'. The dependent and explanatory definitions are presented in related sections. The joint test, years test and weak tests are presented as 'Prob>F'. Legends (*) to the right of the coefficients and denote the significance levels (* p<0.1; ** p<0.05; *** p<0.01).

4.5.2. CG reform and stock-market allocations, 2000–2008

In this section, we assess the effect of overall CG reform on selected indices of firm value in Russia. Since information on whether a firm is listed on an international stock exchange is generally time-invariant, we are assuming that the 2008 information on whether a Russian firm is listed on an international stock exchange is also pertinent for all the years between 2000 and 2008. Accordingly, we shall, in this subsection, consider the estimates of Eq. (4.2) for the same Russian listed firms as in Section 4.1, but for the longer period of 2000–2008. The various specifications of the panel data estimates of Tobin's Q are summarised in Table 4.9.

First, an introduction of CG codes is associated with significantly higher values of Tobin's Q (irrespective of the definition). In contrast, internationally listed companies tend to have a significantly higher Tobin's Q. There is thus evidence from our analysis that, *ceteris paribus*, internationally (relative to domestically) listed Russian firms tend to have significantly higher firm value in our sample. However, the interaction term measuring the mean impact of the CG reform turns out to be statistically insignificant; in other words, there is no evidence from our sample that internationally listed Russian firms enjoyed higher firm value in the post-CG reform period in our sample, after holding other factors constant.

To summarise, these estimates again confirm the limited effectiveness of the introduction of CG codes in Russia, even when we pool all sectors together. Given that there is evidence of an increase in T&D indices in our sample (see the discussion in Section 4.1), we argue that the introduction of the CG reform in 2004 has not been associated with a statistically significant increase in firm value; the latter can be attributed to the conflict of interest between the controlling owner and the state, which intervenes in private businesses through excessive taxes. It can also be attributed to the conflict of interest between the central and local governments in a decentralised set up, which may not only impose a high bribery cost for helping private businesses to evade central taxes, but may also drive parts of some private businesses underground in a desperate attempt to avoid paying taxes.

Table 4.9: Estimates of Tobin's Q:
CG dummy and stock-market allocations for all industries and the energy industry, 2000–2008

	Pooled OLS 1	OLS-RE 2	OLS-FE 3	First difference (robust clustered) 4	GMM (inclusion of lagged dependent) 5
A. All industries					
CG dummy	0.104	0.104	**0.928*** **	**1.127*** **	**1.459*** **
	(0.149)	(0.184)	(0.260)	(0.269)	(0.396)
Listed internationally dummy	0.571	**0.571***			**0.423***
	(0.488)	(0.593)			(0.463)
CG*Listed internationally dummy	**-0.721***	-0.721	-0.494	-0.591	-0.558
	(0.401)	(0.509)	(0.502)	(0.690)	(0.527)
Herfindalh index	**-0.0489*** **	**-0.0489*** **	**-0.0425*** **	**-0.0459*** **	**0.0690*** **
	(0.00826)	(0.00914)	(0.00895)	(0.00832)	(0.0169)
Total assets	**-0.358*** **	**-0.358*** **	**-0.644** **	0.113	**-0.133** **
	(0.0859)	(0.0778)	(0.271)	(0.353)	(0.0553)
Liabilities to total assets	**-0.887***	-0.887	0.597	0.453	**-0.843***
	(0.518)	(0.550)	(0.853)	(0.943)	(0.457)
Firm age	-0.00281	-0.00281	**-0.240*** **		-0.000892
	(0.00286)	(0.00445)	(0.0852)		(0.00261)
Lag of dependent Tobin's Q					**0.301*** **
					(0.0904)
Constant	10.40***	10.40***	18.06***	-0.466***	-3.468*
	(1.545)	(1.338)	(2.860)	(0.122)	(1.900)
Observations	220	220	220	166	175
Number of companies	54	54	54	52	53
Joint test	0.0000	0.0000	0.0000	0.0000	0.0030
Hausman test			0.0005		
Weak instrument					0.0010
B. Energy industry					
CG dummy	0.194	0.194	**1.053*** **	**1.224*** **	**1.288*** **
	(0.148)	(0.186)	(0.260)	(0.280)	(0.382)
Listed internationally dummy	0.293	0.293	**0.293***	dropped	0.0848
	(0.588)	(0.599)	(0.578)		(0.452)
CG*Listed internationally dummy	-0.455	-0.455	-0.259	-0.573	0.0660
	(0.483)	(0.513)	(0.503)	(0.707)	(0.518)
Herfindalh index	**-0.0326*** **	**-0.0326*** **	**-0.0297*** **	**-0.0334*** **	**0.0481*** **
	(0.00672)	(0.00759)	(0.00736)	(0.00692)	(0.0133)
Total assets	**-0.364*** **	**-0.364*** **	**-0.668** **	0.101	**-0.138** **
	(0.0866)	(0.0790)	(0.276)	(0.361)	(0.0559)
Liabilities to total assets	-0.867	-0.867	0.701	0.516	**-0.910***
	(0.528)	(0.561)	(0.868)	(0.963)	(0.462)
Firm age	-0.00314	-0.00314	**-0.258*** **	dropped	-0.000308
	(0.00305)	(0.00451)	(0.0870)		(0.00264)
Lag of dependent Tobin's Q					**0.270*** **
					(0.0910)
Constant	**-5.869*** **	**9.775*** **	**18.20*** **	**-0.489*** **	-2.522
	(1.168)	(1.375)	(2.919)	(0.125)	(1.850)
Observations	220	220	220	220	175
Number of companies	54	54	54	54	53
Joint test	0.0003	0.0000	0.0000	0.0000	0.0031
Hausman test			0.0001		
Weak instruments					0.030

Note: White's standard errors are applied to control for heteroscedasticity.

This table demonstrates the further objective we would like to assess, which is the implication of CG mechanism implementation on firm value, controlling for explanatory measures and, additionally, controlling for stock-market allocation. The regression results are based on various panel data specifications, which are presented in detail within the theoretical methodology section, as discussed in Chapter 2. The main dependent variable is defined as 'firm market capitalisation divided by total assets'. The dependent variable and explanatory measures definitions are presented in the relevant sections. The joint test, years test and weak tests are presented as 'Prob>F'. Legends (*) to the right of the coefficients denote the significance levels (* p<0.1; ** p<0.05; *** p<0.01).

4.6. Concluding comments

Using recent firm-level panel data from Russia, this chapter investigates whether an introduction of CG codes would necessarily boost firm value. We argue that an understanding of CG in Russia requires an identification of the conflict of interests, not only between the controlling and minority owners, but also between the controlling owners and the centralized state as well as that between the central and local governments in a decentralised set-up. The state may not only act as the stakeholder of a company, but also has the tax-setting power. While the introduction of CG codes may increase firm value by resolving the conflict of interest between the controlling and minority owners in Russia's highly concentrated ownership structure, introduction of tax reforms, stringent tax enforcement and decentralisation may counteract the CG reforms. Consequently, the net effect of the introduction of CG codes may be positive, negative or have no effect at all, when the positive and negative effects exactly outweigh each other.

Unlike many existing studies, our analysis has been facilitated by the recent availability of S&P data on T&D for the top-listed firms in Russia for the period of 2003–2007. We were able not only to consider Russian energy firms, but also to compare the specific cases of Russia's non-energy sector companies. Even within the energy sector, we have been able to compare the cases of the utilities and oil and gas subsectors for their obvious contributions (significance) to the Russian economy. There is evidence from our panel data estimates that the various T&D rules have met with only limited success in terms of boosting firm value, especially for the all-important oil and gas sector. This is because CG reforms initiated a conflict of interest between the large energy giants and the centralized state, while the tax reforms and decentralisation generate the conflict of interest between the central and local governments. The impact of the introduction of the CG code is even weaker when we examine the impact of the introduction of CG codes (which include broader measures over and above T&D rules) in 2002 (which became effective from 2004 onwards) on various indices of firm value, after exploiting the variation in the impact of the code between domestic and internationally listed Russian firms in our sample for 2000–2008: while the CG dummy remains insignificant in determining firm value, *ceteris paribus*, internationally listed Russian firms tend to have significantly higher market value. There is, however, no significant differential positive effect of CG reform on firm value among internationally listed firms; consequently, the average impact effect turns out to be insignificant. We argue that these results support our central hypothesis and also complement Desai, Dyck and Zingales (2007), who argued that stringent tax enforcement can increase the amount outside shareholders will receive, even when accounting for increased levels of taxation. We argue that higher taxes, stringent tax enforcement and fiscal decentralisation may generate a conflict of interest between the controlling owner and the state and also between the central and local governments, which may counteract the effectiveness of other CG reforms. Although this is a case study of Russia, the results from this study have wider implications beyond the country, especially in other central and eastern European countries as well as the countries from the community of independent states (CIS), where state control over private businesses often remains firm even after radical privatisation programmes. This conflict of interest between Russian corporate oligarchs and the state has induced many Russian oligarchs to invest abroad. The latter, in turn, have gradually been paving the way for increasing inward foreign investment in Russia, as highlighted by the recent BP deal in the oil and gas sector of the country. It would be interesting to see whether and how inward foreign multinational investment can resolve the conflict of interest between the state and the controlling private owners, thus contributing to sustained improvement in firm value in Russia.

Appendix 4.A: Detailed regression estimates for various controls

Table 4.A.1: Estimates of Tobin's Q (alternative proxy): T&D overall for all industries and the energy sector, 2003–2007

	Pooled OLS 1	OLS-RE 2	OLS-FE 3	First difference (robust clustered) 4	GMM (inclusion of lagged dependent) 5
A. All industries (energy and non-energy)					
T&D overall	1.409	**1.409****	**1.366***	**2.295*****	0.274
	(0.998)	(0.714)	(0.785)	(0.866)	(0.496)
Herfindalh index	**-0.0140****	-0.0140	0.0204	0.0156	**0.0278*****
	(0.00615)	(0.00855)	(0.0144)	(0.0116)	(0.00968)
Total assets	**-0.316****	**-0.316****	**-0.556****	0.112	**-0.135*****
	(0.157)	(0.127)	(0.272)	(0.327)	(0.0499)
Liabilities to total assets	-0.446	-0.446	-0.563	-0.498	-0.532
	(0.584)	(0.664)	(0.801)	(1.004)	(0.405)
Firm age	-0.00161	-0.00161	**0.260*****		0.000849
	(0.00530)	(0.00808)	(0.0958)		(0.00238)
Lag of dependent Tobin's Q					**0.269*****
					(0.0840)
Constant	**7.090*****	**7.090*****	2.270	0.0743	0.913
	(2.395)	(2.059)	(3.764)	(0.117)	(1.204)
Observations	136	136	136	83	137
Number of companies	51	51	51	36	52
Joint test	0.0148	0.0318	0.0213	0.0000	0.0010
Hausman test			0.0229		
Weak instruments					0.0000
B. Energy industry					
T&D overall	1.448	**1.448****	**1.371***	**2.303*****	0.256
	(1.000)	(0.715)	(0.788)	(0.869)	(0.500)
Herfindalh index	**-0.00956****	-0.00956	0.0127	0.00920	**0.0188****
	(0.00486)	(0.00652)	(0.00989)	(0.00784)	(0.00751)
Total assets	**-0.308****	**-0.308****	**-0.550****	0.120	**-0.141*****
	(0.156)	(0.127)	(0.272)	(0.328)	(0.0502)
Liabilities to total assets	-0.429	-0.429	-0.562	-0.509	-0.549
	(0.582)	(0.665)	(0.804)	(1.007)	(0.407)
Firm age	-0.00145	-0.00145	**0.237*****		0.000797
	(0.00527)	(0.00809)	(0.0879)		(0.00239)
Lag of dependent Tobin's Q					**0.253*****
					(0.0846)
Constant	**6.800*****	**6.800*****	3.009	0.0493	1.348
	(2.378)	(2.028)	(3.578)	(0.111)	(1.181)
Observations	136	136	136	83	137
Number of companies	51	51	51	36	52
Joint test	0.0373	0.0400	0.0244	0.0450	0.0020
Hausman test			0.0199		
Weak instruments					0.0120

Note: White's standard errors are applied to control for heteroscedasticity.

This table demonstrates the main objective as per Table 4.4 but with an alternative Tobin's Q measure; that is, the implication of T&D overall implementation for firm value, controlling for explanatory measures and, additionally, controlling for stock-market allocation. The regression results are based on various panel data specifications, which are presented in detail within the theoretical methodology section, as discussed in Chapter 2. The alternative dependent is defined as 'firm market capitalisation including debt divided by total assets'. The dependent and explanatory definitions are presented in the relevant sections. The joint test, years test and weak tests are presented as 'Prob>F'. Legends (*) to the right of the coefficients denote the significance levels (* $p<0.1$; ** $p<0.05$; *** $p<0.01$).

Table 4.A.2: Estimates of Tobin's Q: T&D overall for non-energy industries, 2003–2007

	Pooled OLS 1	OLS-RE 2	OLS-FE 3	First difference (robust clustered) 4	GMM (inclusion of lagged dependent) 5
A. T&D overall					
T&D overall	0.821	0.821	1.086	**2.059****	**0.5470***
	(0.897)	(0.690)	(0.771)	(0.861)	(0.370)
Herfindalh index	**-0.0408*****	**-0.0408*****	**-0.0752****	**-0.0533****	**0.0456*****
	(0.00818)	(0.0107)	(0.0306)	(0.0253)	(0.00912)
Total assets	**-0.441*****	**-0.441*****	**-0.586****	0.100	**-0.6680***
	(0.148)	(0.123)	(0.265)	(0.325)	(0.0376)
Liabilities to total assets	-0.863	-0.863	-0.556	-0.119	**-0.672****
	(0.640)	(0.635)	(0.788)	(1.001)	(0.324)
Firm age	-0.00388	-0.00388	-0.162		0.00114
	(0.00538)	(0.00786)	(0.145)		(0.00180)
Lag of dependent Tobin's Q					**0.421*****
					(0.0653)
Constant	**9.982*****	**9.982*****	**16.86*****	-0.217	-0.701
	(2.391)	(1.991)	(5.217)	(0.136)	(0.907)
Observations	137	137	137	83	138
Number of companies	52	52	52	36	52
Joint test	0.0000	0.0001	0.0001	0.0234	0.0100
Hausman test			0.0068		
Weak instruments					0.0030
B. T&D financial & operational information					
T&D fin. & oper.	0.917	**0.917***	**1.022***	**1.439****	-0.0130
	(0.769)	(0.523)	(0.564)	(0.656)	(0.326)
Herfindalh index	**-0.0400*****	**-0.0400*****	**-0.0724****	**-0.0491***	**0.0458*****
	(0.00803)	(0.0105)	(0.0305)	(0.0256)	(0.00908)
Total assets	**-0.444*****	**-0.444*****	**-0.591****	0.0615	**-0.0659***
	(0.147)	(0.121)	(0.261)	(0.331)	(0.0378)
Liabilities to total assets	-0.893	-0.893	-0.656	-0.366	**-0.669****
	(0.634)	(0.631)	(0.780)	(1.012)	(0.311)
Firm age	-0.00400	-0.00400	-0.148		0.00114
	(0.00534)	(0.00785)	(0.144)		(0.00180)
Lag of dependent Tobin's Q					**0.422*****
					(0.0655)
Constant	**9.927*****	**9.927*****	**16.53*****	-0.178	-0.733
	(2.428)	(1.979)	(5.168)	(0.137)	(0.900)
Observations	137	137	137	83	138
Number of companies	52	52	52	36	52
Joint test	0.0000	0.0000	0.0024	0.0352	0.0000
Hausman test			0.0071		
Weak instruments					0.0000

Note: White's standard errors are applied to control for heteroscedasticity.

This table is a continuation of Tables 4.4 and 4.6 but demonstrates the implication of T&D overall and financial and operational information implementation for firm value, controlling for explanatory measures for the non-energy sectors. The regression results are based on various panel data specifications, which are presented in detail within the theoretical methodology section, as discussed in Chapter 2. The main dependent is defined as 'firm market capitalisation divided by total assets'. The dependent and explanatory definitions are presented in the relevant sections. The joint test, years test and weak tests are presented as 'Prob>F'. Legends (*) to the right of the coefficients denote the significance levels (* p<0.1; ** p<0.05; *** p<0.01).

Appendix 4.B: Construction of T&D indices from 2003–2007 by S&P

The T&D survey was conducted by the S&P. S&P uses only publicly available information, thus emphasising that a company's transparency score should not be compared with its CG score (CGS), or otherwise interpreted as a measure of governance standards. A CGS is our assessment of a company's CG practices, which is not limited to information disclosure. In addition, these scores are assigned on the basis of an in-depth, interactive analytical process involving both public and non-public data.

Number of companies included

The latest 2007 study covers 80 of the largest public Russian companies with the most liquid stock. In 2006, S&P analysed 70 companies. In 2005, 2004 and 2003, the survey covered 54, 50 and 45 companies, respectively.

Criteria to select companies

S&P used two criteria to select the companies in the study: size and liquidity. As a rule, the liquidity of stocks positively depends on the size of the company, but there are exceptions, especially in cases of a minor free-float. There are more than 300 public companies in Russia, and this sample may not be representative of all Russian public companies. As the larger companies tend to be more transparent than smaller ones, our sampling method is likely to cause an upward bias in assessing transparency of the entire population of public Russian companies. On the other hand, as the companies included in the survey account for about 80% of the cumulative capitalisation of the Russian Stock Market, they represent the major part of the Russian economy in terms of assets and operations.

S&P's covered industries

S&P covers such industries as telecommunications, metallurgy, utilities, oil and gas, banking, food, consumer and retail markets and IT engineering. In our analysis, we classify these industries between energy and non-energy sectors and compare those with all industries together. We apply GICS codes to classify firms in our sample. As we focus on the energy industry, GICS allowed us to identify nine main energy subsectors within the energy industry. We have selected utilities and oil and gas producers as the two largest ones, consisting of 64% of the entire energy sector. We provide companies sectoral breakdown in Appendix 4.C.

Components of T&D indices and scoring

S&P have introduced six components and grouped these into three T&D scores. Subject to these clarifications, these are:

- T&D ownership structure and shareholders rights
- T&D financial and operational information
- T&D board and management structure

The first T&D score consists of "ownership structure" and "shareholder rights", which are represented by 17 questions each. The next T&D score is a composition of "financial information" and "operational information" disclosure. These are based on 31and 16 questions, respectively. The last T&D score consists of "board and management information" and "board and management remuneration", based on 16 and 8 questions. S&P then calculated the scores for each answer in every section and provided the total scores for each T&D for the observed companies. The score has a range of 0% to a maximum of 100% for the best T&D. S&P does not explain the methodology behind the percentage score as it uses a specially designed method. We show the T&D scorings for each observed company in Appendix 2.

Component 1. Ownership structure

Disclosure of:

1. The number and par value of issued ordinary shares.
2. The number and par value of issued other types of shares disclosed.
3. The number and par value of authorised but unissued shares of all types.
4. The identity of the largest shareholder.
5. The identity of holders of all large stakes (blocking: > 25%; controlling: > 50%).
6. The identity of shareholders holding at least 25% of voting shares in total.
7. The identity of shareholders holding at least 50% of voting shares in total.
8. The identity of shareholders holding at least 75% of voting shares in total.
9. The number and identity of each shareholder holding more than 10%.
10. The indication that management is not aware of the existence of any stake exceeding 5% except for those that are reported.
11. Shareholding in the company by individual senior managers.
12. Shareholding in the company by individual directors.
13. The description of share classes.
14. A review of shareholders by type.

15. The percentage of cross-ownership.
16. Information about listings on exchanges.
17. Information about indirect ownership (e.g., convertible instruments).

Component 2. Shareholder rights

Disclosure of:
18. Corporate governance charter or corporate governance guidelines.
19. Evidence of existence of a code of business conduct and ethics.
20. The contents of the code of business conduct and ethics.
21. Articles of association (including changes).
22. Voting rights for each voting or nonvoting share.
23. The way that shareholders nominate directors to the board.
24. The way that shareholders convene an extraordinary general meeting (EGM).
25. Procedure for initiating inquiries with the board.
26. Procedure for putting forward proposals at shareholders' meetings.
27. Formalized dividend policy.
28. Announcement of recommended dividends before the record date.
29. Review of the last shareholders' meeting.
30. Full general shareholder meeting (GSM) minutes.
31. Calendar of important shareholder future dates.
32. GSM materials published on the Web site.
33. Detailed press releases covering last corporate events.
34. Policy on information disclosure.

Component 3. Financial information

Disclosure of:
35. The company's accounting policy.
36. The accounting standards it uses for its accounts.
37. Accounts according to local standards.
38. Annual financial statements according to an internationally recognised accounting standard (IFRS/U.S. GAAP).
39. Notes to annual financial statements according to IFRS/U.S. GAAP.

40. Independent auditor's report on annual financial statements according to IFRS/U.S. GAAP.

41. Unqualified (clean) audit opinion on annual financial statements according to IFRS/U.S. GAAP.

42. Audited IFRS/U.S. GAAP financial statements published before the end of April.

43. Unaudited IFRS/U.S. GAAP financial statements published before the end of April.

44. Audited IFRS/U.S. GAAP financial statements published before annual general meeting.

45. Unaudited IFRS/U.S. GAAP financial statements published before the end of June.

46. Disclosure of related-party transactions (RPTs): sales to/purchases from payables to/receivables from related parties.

47. Indication that RPTs are made on market or nonmarket terms.

48. Exact terms of RPTs.

49. Interim (quarterly or semi-annual) financial statements according to an internationally recognised accounting standard (IFRS/U.S. GAAP).

50. Notes to these financial statements.

51. Whether these financial statements are audited or at least reviewed.

52. Consolidated financial statements according to the local standards.

53. Methods of asset valuation.

54. A list of affiliates in which the company holds a minority stake.

55. The ownership structure of affiliates.

56. A basic earnings forecast of any kind.

57. A detailed earnings forecast.

58. Segment analysis (results broken down by business line).

59. Revenue structure (detailed breakdown).

60. Cost structure (high degree of detail).

61. The name of the auditing firm.

62. Whether the audit firm is a top-tier auditor.

63. Auditor rotation policy.

64. How much the company pays in audit fees to the auditor.

65. Whether auditor renders non-audit services.

66. Non-audit fees paid to the auditor.

Component 4. Operational information

Disclosure of:

67. Details of the type of business the company is in.
68. Details of the products or services the company produces or provides.
69. Output in physical terms.
70. A description of functional relationships between key operating units within the group.
71. Industry indicators that allow comparison with peers.
72. Other financial indicators.
73. Characteristics of fixed assets employed (including licenses).
74. Efficiency indicators.
75. A discussion of corporate strategy.
76. Any plans for investment in the coming years.
77. Detailed information about investment plans in the coming year.
78. An output forecast of any kind.
79. An overview of trends in its industry; regulatory environment with regards to industry.
80. The market share for any or all of the company's businesses.
81. Social reporting (e.g., Global Reporting Initiative).
82. Overview of compliance with environmental law.
83. Principles of corporate citizenship.

Component 5. Board and management information

Disclosure of:

84. The list of board members (names).
85. Details about the current employment and position of directors.
86. Other details: previous employment and positions, education etc.
87. When each director joined the board.
88. The name of the chairman.
89. Details about role of the board of directors at the company.
90. A list of matters reserved for the board.
91. A list of board committees.
92. Names of all members of each existing committee.
93. The bylaws on other internal audit functions besides the audit committee.
94. Information about the ratio of in absentia and in person board meetings.

95. Attendance record for board meetings.

96. The list of senior managers not on the board of directors.

97. The backgrounds of senior managers.

98. The non-financial details of the CEO's contract.

99. The number of shares held in other affiliated companies by managers.

100. Policy on assessment of board of directors and on training provided to them.

Component 6. Board and management remuneration

Disclosure of:

101. The decision-making process for directors' pay.

102. The specifics of directors' pay, including the salary levels.

103. The form of directors' salaries, such as whether they are in cash or shares.

104. The specifics of performance-related pay for directors.

105. The decision-making process for determining managerial (not board) pay.

106. The specifics of managers' (not board) pay, such as salary levels and bonuses.

107. The form of managers' (not board) pay.

108. The specifics of performance-related pay for managers.

Appendix 4.C: T&D scores by companies, 2003–2007

Companies sectoral breakdown		Ownership structure and shareholders' rights, %					Financial and operational information, %					Board and management structure and process, %					Overall T&D score, %				
		2003	2004	2005	2006	2007	2003	2004	2005	2006	2007	2003	2004	2005	2006	2007	2003	2004	2005	2006	2007
All sectors (69 companies; energy & non-energy)	Mean	0.44	0.50	0.50	0.54	0.55	0.45	0.47	0.53	0.58	0.57	0.41	0.46	0.50	0.49	0.50	0.44	0.47	0.51	0.54	0.55
	St Dev.	0.20	0.20	0.19	0.16	0.16	0.19	0.22	0.20	0.17	0.15	0.17	0.17	0.16	0.14	0.14	0.17	0.18	0.19	0.14	0.13
1. Energy sector (36 companies)	Mean	0.40	0.43	0.46	0.52	0.53	0.43	0.41	0.50	0.56	0.57	0.39	0.43	0.47	0.48	0.49	0.41	0.42	0.48	0.52	0.55
	St Dev.	0.10	0.18	0.16	0.16	0.15	0.13	0.21	0.19	0.19	0.16	0.10	0.17	0.16	0.13	0.12	0.09	0.18	0.17	0.14	0.13
Energy sector – Utilities (10 companies)	Mean	0.37	0.45	0.43	0.50	0.53	0.38	0.39	0.43	0.46	0.50	0.36	0.44	0.44	0.53	0.50	0.37	0.42	0.43	0.49	0.51
	St Dev.	0.09	0.14	0.13	0.09	0.11	0.14	0.18	0.13	0.16	0.13	0.09	0.14	0.12	0.11	0.13	0.09	0.15	0.13	0.11	0.11
1.2. Energy sector - Oil and gas producers (13 companies)	Mean	0.41	0.43	0.47	0.50	0.49	0.47	0.40	0.50	0.58	0.58	0.40	0.43	0.52	0.43	0.45	0.43	0.41	0.50	0.52	0.54
	St Dev.	0.09	0.23	0.17	0.21	0.20	0.12	0.27	0.21	0.21	0.16	0.12	0.25	0.16	0.16	0.14	0.08	0.24	0.18	0.18	0.17
1.3. Energy sector - Other (13 companies)	Mean	0.43	0.41	0.47	0.55	0.58	0.47	0.44	0.56	0.64	0.62	0.44	0.42	0.44	0.48	0.53	0.45	0.43	0.50	0.57	0.59
	St Dev.	0.16	0.18	0.22	0.15	0.10	0.15	0.19	0.22	0.16	0.16	0.09	0.09	0.20	0.09	0.09	0.13	0.15	0.21	0.13	0.10
2. Non-energy sector (33 companies)	Mean	0.48	0.57	0.53	0.58	0.56	0.48	0.55	0.57	0.61	0.57	0.43	0.50	0.53	0.50	0.51	0.46	0.54	0.54	0.57	0.56
	St Dev.	0.26	0.20	0.21	0.18	0.18	0.24	0.22	0.22	0.15	0.14	0.22	0.16	0.15	0.16	0.16	0.23	0.18	0.20	0.14	0.13

Source: S&P Reports (various).

This table provides three T&D indices and its scores between 0% for worth relating to T&D to the maximum of 100% for the best corporate performance. All the information obtained from S&P studies pertain to 2003 and 2007. Companies are classified using the GICS industry classification. The energy firms are represented by a sample of 36 firms, where non-energy industry is covered by 33 companies. We have focused on the two largest energy sectors – utilities and oil and gas producers – and organised other energy sectors in the 'other energy' section. These two largest energy sectors consist of 23 companies, where other energy sectors is represented by 13 companies. We also compare energy firms with 33 non-energy companies, which cover such industries as telecommunications, metallurgy, utilities, oil and gas, banking, food, consumer and retail markets and IT engineering.

CHAPTER 5

5. Resource abundance, resource rents, corruption and FDI: A country panel analysis

Abstract

This chapter examines whether and how the introduction of natural resource abundance and corruption determine primary FDI. It is argued that the attraction of primary FDI not only depends on higher economic gains received compared to other industries, but also on whether the environment of corruption allows for investors and governments to protect the returns when engaging in capital investments. Using a panel of countries for 1992–2001, we find that the introduction of corruption significantly reduces the attraction for natural resource activities and, therefore, significantly affects primary FDI inflows. However, the effects of natural rents and corruption remain insignificant for total FDI, even after controlling for other commonly used factors of FDI.

5.1. Introduction

Existing research suggests that FDI is a good instrument of economic policy, providing the potential for economic growth. The general argument in favour of FDI is that it fosters the economic development of a country. Nevertheless, the studies highlight the issues of allocating FDI according to the expected profitability of the investments, in particular, for those natural resource-rich countries where the natural resources provide higher economic rents compared to other industries (Dunning, 1974 and 1980; World Bank, 2006; Bhattacharyya and Hodler, 2009; Poelhekke and Van der Ploeg, 2010). Further, it is emphasised that corruption exists at every stage of natural resource activity, from pre-exploration activities and licensing agencies to complex financial arrangements, because corruption allows for investors to protect their returns and for governments to stay in power (Bloningen, 2005). From this perspective, the present chapter examines the complex relationship between natural resource activity, corruption and FDI inflows in the primary industry.

In the context of natural resource abundance and corruption, we investigate three hypotheses:

- Whether greater access to natural resources promotes primary FDI inflows.
- Whether greater corruption increases or decreases inward FDI in the primary sector.
- Whether the effect of natural resource activity on primary FDI depends on the extent of corruption (the interaction between natural resource activity and corruption).

The examination of these hypotheses advances on existing studies, which showed that the extent of institutional mechanisms may or may not lead to lower or higher primary FDI inflows, so that the impact of both resource activity and corruption on FDI is unclear.

Most previous studies focused on aggregate FDI levels (Smarzynska and Wei, 2000; Bloningen, 2005) and outward resource investments (Poelhekke and van der Ploeg, 2010). Only a limited number of studies pertained to natural resource investments, and even fewer explored the effect of natural resource abundance on primary FDI. In our study, we consider the resource-seeking FDI inflows into the country. While it might be expected that the presence of natural resources in a country may boost resource-seeking FDI, some resource-rich countries are more successful than others (Acemoglu et al., 2004; Kinoshita and Campos, 2010). Conversely, Dunning’s ownership-location-internationalisation (OLI) paradigm postulates that natural resource abundance is the major factor for attracting FDI to resource-rich countries because of the higher economic gains received compared to investments in other industries (Dunning, 1974 and 1980).

We found some evidence that the presence of corruption significantly reduced the attraction of natural resource rents and, therefore, significantly impacted primary FDI inflows. However, the effect of natural rents and corruption remains insignificant for total FDI, even after controlling for other measures. The latter perhaps may be explained by the weak natural resource rents exposure beyond the primary sector; there are few countries demonstrating successful use of the rent gains in terms of distribution to other industries, mainly because of good governance practice being in place (Hausman and Rigobon, 2002; Kinoshita and Campos, 2010; Poelhekke and van der Ploeg, 2010).

Our analysis contributes to a growing literature on natural resource abundance and corruption for primary FDI investments. In two pioneering studies, Dunning (1974, 1980) highlighted how factors such as ownership, location and internationalisation create preconditions for international investments, where primary FDI pertains to the resource-seeking motives. While earlier literature tended to focus on the aggregated FDI (Smarzynska and Wei, 2000; Bloningen, 2005), in the recent literature, the focus has shifted to natural resource foreign capital investments (Asiedu and Lien, 2011; Poelhekke and van der Ploeg, 2010). Academic literature also suggests that although each primary FDI targets its specific interests, in general, access to resources, availability of cheap labour, high economic value from the natural rents received compared to other industries, legal stability and a low level of bureaucracy and corruption attract higher levels of FDI. For instance, Asiedu (2002) and, later, Asiedu and Lien (2011) linked resource activity with democracy effects. In another study, Kronenberg (2004) explored the effect of natural resource intensity on economic development but not on FDI. In a more recent paper, Bhattacharyya and Hodler (2009) focused on the relations between natural resources and corruption. Poelhekke and van der Ploeg (2010) and van der Ploeg (2011) explored the effect of natural resources on FDI through institutional quality, but the authors considered aggregated FDI, not primary FDI. The general agreement is that resource abundance and the resulting potential economic benefits both influence and are influenced by the institutional environment. We go beyond this literature in that, in the absence of prior evidence, we are able to identify possible ways through which the introduction of access to natural resources can influence FDI inflows in the primary sector. In doing so, our analysis highlights that corruption is especially prone to primary FDI decision making after controlling for other factors. We are not aware of any existing study that pertains to the effect of natural resources and corruption on the primary FDI inflows.

Our analysis focuses on a panel of 136 countries that are natural resource-rich, covering the period from 1992 to 2001, based on inward FDI data availability from the UNCTAD database. We merged FDI data compiled by UNCTAD with natural resource activity measures, corruption proxies and other control variables extracted from World Bank World Development Indicators (WBWDI) and ICRG databanks. Section 4.2 refers to the discussion of selected measures. We used FDI inflows to GDP ratio as a dependent variable in our estimations, which is a commonly applied FDI measure (Poelhekke and van der Ploeg, 2010; Asiedu and Lien, 2011). In regard to natural resource activity, we used the ratio of natural resource rents to GDP (World Bank, 2006; Bhattacharyya and Hodler, 2009) and for the corruption measure we have applied the generally accepted ICRG proxy for financial corruption and excessive patronage (Poelhekke and van der Ploeg, 2010; Asiedu and Lien, 2011). These natural resource activity and corruption measures are the regression variables, and their selection is driven by the quantity of data for the countries in our sample in order to minimise the risk of sample selection bias and to cover a wider time dimension.

To identify accurately the effect of natural resource activity and corruption in terms of FDI inflows, we have introduced control measures, comprising of factors that are likely to impact on FDI inflows including trade openness (natural log of % of GDP), GDP per capita (natural log), level of credits obtained from banking institutions, military power in the state and number of telephone lines per 100 citizens as a control for infrastructure (Asiedu, 2002; Alfaro et al., 2004; Caselli and Cunningham, 2009; Kinoshita and Campos, 2010; Asiedu and Lien, 2011). In addition to performing estimations for resource-based FDI investments, we compared the results with the overall FDI inflows in the countries.

We have started with OLS and included a random effect, a fixed effects option, and first-difference models and presented results as elasticity in accordance with the theoretical background in Chapter 2. In addition, we proceeded with a GMM estimator. We did this because the inclusion of the lagged dependent FDI measure on the right-hand-side (RHS) of the equation may bias the OLS estimates, as the lagged dependent is correlated with country specific characteristics. The GMM estimator should remove the country fixed effects through the differencing, and any endogeneity that might arise due to a correlation of country FE and explanatory variables will be removed (Arellano and Bond, 1991).

The chapter is developed as follows. Section 5.2 establishes hypotheses of the effect of natural resource activity and corruption on primary FDI inflows. Section 5.3 describes data and Section 5.4 refers to methodology. Section 5.5 presents and analyses the results, and Section 5.5 concludes.

5.2. Hypotheses

Three hypotheses are developed in this section. The first hypothesis concerns whether greater access to natural resources may promote inward FDI in the primary sector. The second hypothesis examines whether greater corruption may increase or decrease inward FDI in the primary sector. The third hypothesis concerns determining whether the effect of natural resources on primary FDI depends on the extent of corruption in the country.

5.2.1. H1: Greater access to natural resources may promote inward FDI in the primary sector

The eclectic paradigm of internationalisation merged various isolated theories of international economies into one and highlighted the importance of Dunning's seminal OLI paradigm factors as preconditions for any international activities.

Dunning (1974, 1980) particularly distinguished FDI as being of four types: resource-seeking, market-seeking, efficiency-seeking and strategic-assets-seeking FDI. In this regard, the first type, resource-based investments, concentrate on abundant natural resources and can target local, home or international markets. The main factors in making a resource investment are the existence of the resource, availability of cheap labour and the necessary physical infrastructure, which is supported with empirical studies for the resource-abundant countries (Hausman and Rigobon, 2002; Kinoshita and Campos, 2010). The second type, market-seeking FDI, focuses on existing and new local markets. The determining factor for market-based investments is the size of the market and its potential for growth (van der Ploeg, 2011). The objective of the third type, efficiency-seeking FDI, is to gain from close ties between countries. For instance, the European Union benefits from the economic area, which is governed by common legalisation, inter-connected transportation links and flexible movement of labour (Bevan and Estrin, 2000). The fourth type, strategic-asset FDI, is concerned with sustaining and advancing a company or government in international markets. For instance, Wang (2007) highlighted that China is a major economic and trade market for many countries and now pursues policies of strategic outward FDI to develop trade and diversify investment.

Academic literature also suggests that although each type of FDI targets its specific interests, in general, access to resources, market potential, availability of the necessary labour force, current or developable infrastructure, legal stability and a low level of bureaucracy and corruption attract higher levels of FDI. We particularly focus on whether access to resources boosts FDI in the primary sector.

Dunning's OLI paradigm (Dunning, 1974, 1980) postulates that natural resource abundance is the major factor for attracting FDI to resource-rich countries. Dunning's OLI theory states that countries that are rich in natural resources would expect to receive more FDI directed to those resource sectors, compared to other sectors of their economy, because of the high economic value received from the extraction of the natural resources compared to other industries. Measuring the level of primary resource intensity is therefore important in examining resource-seeking FDI. A number of studies control for the intensity of natural resources. Among those who apply resource control in their various proxies are Asiedu (2002), Kronenberg (2004), the World Bank (2006), Bhattacharyya and Hodler (2009), Poelhekke and van der Ploeg (2010), van der Ploeg (2011) and Asiedu and Lien (2011). These studies pursued different motives and therefore used natural activity measures for different purposes. Further, the difference is that the natural resource measures have been dictated by the data availability for the selected country samples and for the time periods observed.

For instance, Asiedu (2002) and later Asiedu and Lien (2011) linked resource activity with democracy effects. These authors used the existence of the proportion of total exports that comes from fuels, minerals and oil as a measure for resource abundance. In a later study, Kronenberg (2004) explored the effect of natural resource intensity on economic development but not on FDI, controlling for resource abundance through the share of primary goods in total exports. In a more recent paper, Bhattacharyya and Hodler (2009) have focused on the relations between natural resources and corruption, but not on FDI, with the application of a log of resource rents per capita from the World Bank with reference to Hamilton and Clements (1999). The two most recent studies by Poelhekke and van der Ploeg (2010) and van der Ploeg (2011) are the closest to our research. These two papers explored the effect of natural resources on FDI through institutional quality, but the authors considered aggregated FDI, not primary FDI. Poelhekke and van der Ploeg (2010) valued the resource presence through the export net of production costs as a dummy variable when the rents were non-zero. Their objective was to measure the resource discovery instead of the resource change over time.

The findings of subsequent studies have shown that it is very likely that resource abundance and the resulting potential economic benefits both influence and are influenced by the institutional environment. However, at this stage, we explore the initial effect of resource abundance on primary FDI and will study the institutional effect by moving to another two hypotheses. Therefore, we propose the first hypothesis: greater access to natural resources may promote inward FDI in the primary sector. As noted earlier, in order to study the further effect of natural resource activity on FDI, we now move to the next hypothesis to explore the effect of corruption as a measure of the cost of doing business.

5.2.2. H2: Greater corruption may increase or decrease inward FDI in the primary sector

Studies on aggregated FDI emphasised that corruption exists at every stage of natural resource wealth creation from pre-exploration activities of the parties involved, including complex financial arrangements, resource concessions, capital lenders, insurance companies, intermediary agencies and governments, to numerous local and international subcontractors (Bloningen, 2005). Corruption captures the extent to which the governmental, institutional and court decisions can be used in favour of investors to protect their returns on investments. The empirical findings are generally mixed, referring both to positive and negative effects between corruption and natural resource activities.

First, Kronenberg (2004), Egger and Winner (2005), Robinson et al. (2006) and Caselli and Cunningham (2009) found a positive relation between corruption and natural resource activities. These studies found that those involved in resource exploitation benefit from high economic gains: investments are not deterred by corruption because the latter allows for the profits to stay with investors. A recent study by Kinoshita and Campos (2010) showed that rich resource-abundant countries such as Azerbaijan, Kazakhstan and Russia have attracted substantial FDI to their resource-based sectors because they are rich in oil and natural gas, although the FDI has had a wider adverse effect on the economic development and social contributions to these countries because of the corruption levels. These results are supported by the earlier study of Hausman and Rigobon (2002) for six large oil-exporting countries of Angola, Iraq, Kazakhstan, Nigeria, Sudan and Venezuela. They found that between 1970 and 2003, these experienced less than half the GDP growth rate compared with other countries because of corruption-related issues.

Second, Smarzynska and Wei (2000), Egger and Winner (2005) and Kronenberg (2004) found a negative effect between corruption and natural resource activities. For instance, Egger and Winner (2005) showed empirical evidence that in the short run, corruption raises the cost of foreign investment, since firms have to pay bribes and bear extra contract risks as corruption contracts are not legally enforceable. However, corruption may also speed up the bureaucratic processes required to obtain legal permissions for setting up a foreign plant or gaining access to publicly funded projects. To this extent, Kronenberg (2004) found that corruption is the main driver in the inefficient use of natural resources in transition countries. The negative effects of corruption on aggregate FDI are also highlighted in Smarzynska and Wei (2000). Their evidence suggests that corruption might have an overall reducing effect on FDI, and in shifting foreign investor involvement towards joint ventures with local firms rather than setting up local subsidiaries, which decreases as the firms become more technologically advanced.

Besides corruption, other measures of institutions are also used. For example, Olson's (1993) findings suggest that democracies, since they tend to allocate the surplus to producers more efficiently, tend to provide more favourable environments for FDI. For instance, both Bhattacharyya and Hodler (2009) and Asiedu and Lien (2011) used democracy as a measure of the quality of state institutions. They found that the quality of democratic institutions has a significant impact on investors' decisions to engage in extractive industries since democracy levels tend to be associated with changes in governmental decisions. Evidence of the institutional significance for capital investments has been found in both recent and earlier studies that focused on the institutional regimes of countries.

To summarise, existing evidence suggests that corruption in the natural resource sector may lead to lower or higher investment activity and less efficient investment allocation, especially if weak institutional mechanisms are in place. While there are studies explaining the effects of institutional factors (e.g. democracy is a common factor) on primary FDI, we are not aware of any study that explains the effect of corruption on primary FDI inflows. That is why, in our study, we emphasise the importance of the empirical evidence relating to the effect of corruption on primary FDI inflows. That is why we propose the second hypothesis: greater corruption may increase or decrease inward FDI in the primary sector. In order to explore further the link between corruption and resource rents, we now move on to our third hypothesis.

Corruption measures

We have placed the discussion on corruption measures separately from the related hypothesis development, for the sake of clarity of the arguments.

In examining the effect of corruption, the studies discussed above used various corruption measures mainly because of the data available for the selected country samples. The most commonly used data in these studies were the corruption proxies obtained from Transparency International (corruption perception index) and ICRG (corruption index).

For instance, Bhattacharyya and Hodler (2009) used the corruption index available from Political Risk Services (PRS) and an alternative corruption perception index from Transparency International. The use of this particular measure is driven by its focus on the political system to study linkages between resource rents and corruption. Bhattacharyya and Hodler (2009) found that democracy affects the level of corruption in relation to natural resources. In another study, using the Transparency International data between 1970 and 2000, van der Ploeg (2011) studied the effect of corruption on natural resources. He signified that countries with conflict over natural resources suffer from corruption and erosion of the quality of the legal system, thus discouraging saving and investment in productive capital. The study found that a control for the effective use of resource rents, corruption, rent-seeking motives and conflicts of interest in attracting effective capital investments should be investigated further.

With regard to ICRG data usage, Poelhekke and van der Ploeg (2010) applied the corruption measure among other indices as a compound measure of institutional quality. The source of this index is ICRG. The authors hypothesised that bad institutions, corruption and risk of expropriation may attract resource FDI because the lack of business transparency allows for the adverse use of the resource rents. They found that corruption among other related indices impacts primary FDI, but has no effect on non-resource investments because the resource-seeking motives relate to the primary sector only. In our study, we employed the same ICRG corruption environment proxy and found that corruption negatively affects the level of both primary and total FDI, although the extent of the effect on total investments is very close to zero.

Among other corruption measures, Kronenberg (2004) applied the ‘state capture index’ from the Business Environment and Enterprise Performance Survey conducted by the World Bank in 1999. His choice of this index was driven by the availability of the countries surveyed. In relation to alternative proxies from other sources such as the OECD, the EBRD and the World Bank (WB), these organisations largely cover different countries and time periods, which is likely to provide insufficient data or to significantly reduce the country sample in relation to the research conducted (Poelhekke and van der Ploeg, 2010).

The relevant literature suggests that the corruption proxy selection is dependent on the index availability for the selected country samples. Among the most commonly used are ICRG’s corruption index and Transparency International’s corruption perception index. In our study, we will employ both corruption variables and present empirical results for the index with the largest available observations and also provide details of the significance of the results.

5.2.3. H3: The effect of natural resources on primary FDI depends on the extent of corruption in the country

The existing literature indicates a complex and multidimensional relationship between corruption, resource rents and FDI inflows. The hypothesised interaction between corruption and natural resources can be studied from two perspectives.

First, corruption allows governments to control governance power and reduce political tensions because natural resources provide high economic rents (e.g., Bourguignon and Verdier, 2000; Acemoglu et al., 2004). High economic rents attract more and more rent seekers, who harm the economy by increasing the number of less-productive entrepreneurs. When governments control these rents, the revenue allows them to promote their political views to the general population, as happened in the mineral-rich Congo (Acemoglu et al., 2004).

Second, highly corrupt, resource-rich countries provide opportunities for wealthy businessmen to obtain import licenses, avoid taxes and buy other privileges from weak government institutions to avoid accountability (Robinson et al., 2006). Thus, a closed, vicious circle is created – corruption breeds FDI, and in natural resources, FDI breeds corruption-related motives because of weak institutional systems (Caselli and Cunningham, 2009). In this chapter, we particularly focus on corruption as an index of institutional quality.

Along these lines, Asiedu and Lien (2011) argued that the effect of natural resources on FDI depends on the nature of political institutions, because FDI tends to be concentrated in extractive industries; a stable policy environment is more favourable to multinational corporations in the extractive industries. In this respect, because of the high capital investment, high uncertainty and a long gestation period are required, and an autocratic regime may be preferred, since democracies tend to be associated with a change in government officials. Furthermore, Asiedu and Lien (2011) found that natural resources tend to be tightly controlled by the government, and, therefore, multinationals need to build closer ties with the government, which are easier to develop in an autocratic regime. Their empirical evidence using cross-country data tends to support the following hypothesis: democracy facilitates FDI if countries have a low share of natural resources in total exports whereas democracy has a negative effect on FDI in countries where exports are dominated by natural resources.

Recent studies by Poelhekke and van der Ploeg (2010) and van der Ploeg (2011) found that the positive effect of natural resources on FDI also depends on institutional quality. However, the activity in the natural resource sector could undermine the positive effect of FDI through a resource bonanza that would drive an appreciation in the real exchange rate and a subsequent decline of resource export sectors, although this evidence was not particularly authoritative. For instance, Poelhekke and van der Ploeg (2010) valued the resource presence through the export net of production costs as a dummy variable when the rents are non-zero. Their objective was to measure the resource discovery instead of the resource change over time. These findings agree with two studies by Asiedu (2002) and Asiedu and Lien (2011), who found that resource activity promotes aggregate FDI under a certain level of democracy in 90 of 122 developing countries for the period 1982 to 2007. These authors used the existence of the proportion of total exports that comes from fuels, minerals and oil as a measure for resource abundance. Similarly, Kronenberg (2004) applied the share of primary goods in total exports, controlling for resource abundance. However, the authors of these studies explored the effect of natural resource activity on economic development, not on FDI investments. In another related study, Bhattacharyya and Hodler (2009) focused on the relationship between natural resources and corruption through the effect of the quality of democratic institutions in 124 countries from 1980 to 2004. They found that democratic institutions significantly influence levels of both natural resource rents and corruption. To examine resource activity, Bhattacharyya and Hodler (2009) applied the log of resource rents per capita from the WB with reference to Hamilton and Clements (1999).

The aforementioned studies not only point to the positive effect of natural resource activity on attracting FDI, but also highlight that the positive effect may be restricted or may even discourage FDI investments. This is supported by Poelhekke and van der Ploeg (2010), who found that natural resource rents may have different effects on primary FDI inflows as the investments may be controlled in some way to prevent too much concentration on the resource sector in order to avoid a possible economic downturn. Conversely, overstimulation can result from states desiring to attract more resource capital in order to obtain more funds for governmental needs. These findings are supported by the earlier study of the WB (2006), which highlighted that resource-abundant countries possess high economic value, added through the use of natural rents. The present study argues that it is important to control for the efficient use of these rents towards the economic development of the country. This is because the natural rents come from natural resources, which are treated as a special economic good that is not produced, but exists naturally. Both studies caution that too much competitiveness may reduce the attractiveness of resource returns and therefore may also distort investments. The WB (2006) defined natural resource rents as the sum of oil rents, natural gas rents, coal rents, mineral rents and forest rents as a percentage of GDP.

The relevant literature reveals a complicated relationship between the corruption environment and resource rents regarding FDI inflows. Thus the following, third hypothesis can be proposed: the effect of natural resources on primary FDI depends on the extent of corruption in the country.

5.3. Data

Our analysis is based on panel data of countries for the period from 1992 to 2001 (unbalanced panel, arranged by panel variable country and time variable year; on a yearly basis). While 142 countries are available with FDI data between 1970 and 2003, the majority of primary FDI data is available for 133 countries between 1991 and 2003[16]. In addition, not all the data on the explanatory variables is available; hence, the countries' sample size is bounded by the data availability and is significantly reduced in size. The data caveat has been discussed within the results section. Given that FDI data is merged with regression measures and other control variables, the estimations are performed for the period of most observations, which is 1992–2001.

They key measures in our study are FDI inflows and three explanatory variables: corruption, natural resource activity and the interaction between the two. Although we have performed estimations of other natural resource activity measures and corruption proxies to test the robustness of our estimations, the results were less significant. Subsections 4.2.1 and 4.2.2 explain the selection of regression variables and control measures employed in this analysis.

The FDI inflows are presented through the ratio to GDP, which is the commonly used FDI proxy (Asiedu and Lien, 2011; Poelhekke and van der Ploeg, 2010). Our main natural resource availability measure is similar to that used by the WB (2006) and Bhattacharyya and Hodler (2009). It is expressed according to the total natural resource

[16] Four FDI inflow types are provided by UNCTAD: general FDI inflows, FDI into primary sector (as mining, quarrying, petroleum exploration, other energy related), FDI into secondary sector (the major ones are food, forestry, metallurgy, machinery, light industry and others) and FDI into tertiary industry (construction, distribution, wholesale, telecoms etc.). FDI inflows are presented in 'other' sectors, but these have fewer observations and do not clarify which sectors these cover. As we focus on FDI in natural resources and its data availability, the World Bank allows us to identify various country groups, but because of data availability, we could not segment to the specific regions – Latin America, the Caribbean, Central Europe and Asia Pacific. In addition, we are able to distinguish between developed, developing and transition countries. However, FDI data has a low number of observations available for Sub-Saharan Africa and transition countries.

rent. The rents are defined as the ratio of the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents and forest rents to the GDP ratio, which is obtained from the WBWDI. The main corruption measure is available from ICRG and is related to financial corruption and excessive patronage. It is scored between 0 and 6, where higher scores on the index imply a less corrupted environment.

We have also employed a range of control variables including trade openness, GDP per capita, loans obtained from banks, influence of military power in the state and infrastructure developments according to the number of telephone lines. Further, we have controlled for lagged FDI among the regression measures.

5.3.1. Regression variables

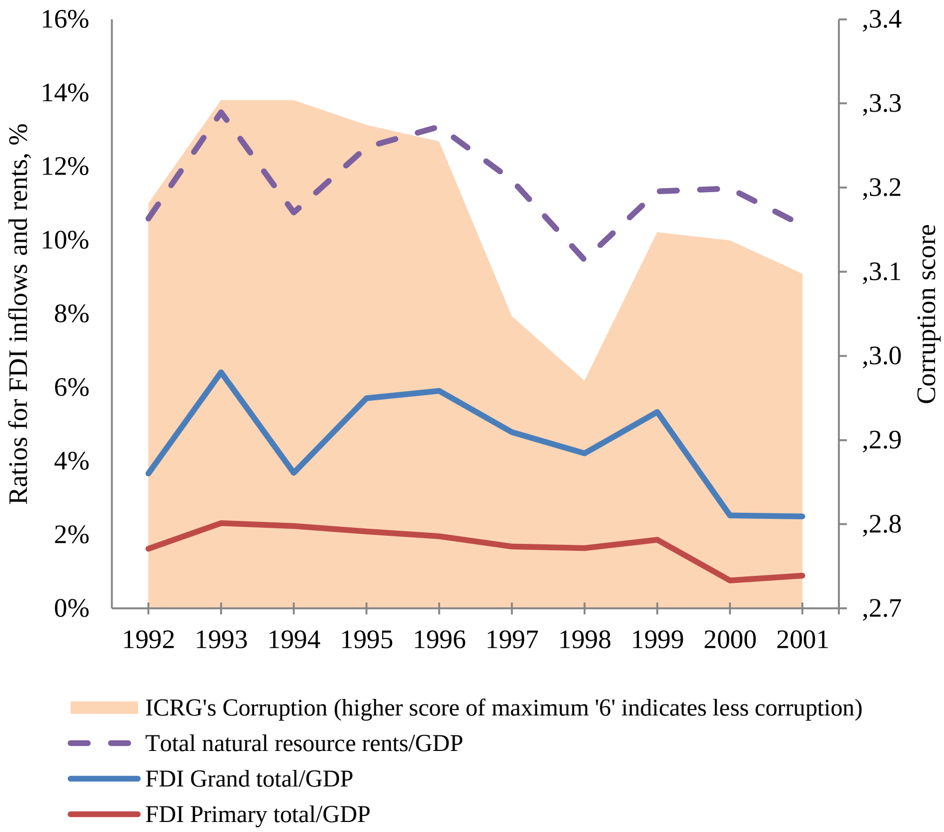
With regard to natural resources, however, like much of the existing literature, we only have access to the widely used share of primary resources to total resources and the natural rents, both of which are available from the WB. However, only the natural rents provide sufficient observations to cover the FDI data. With regard to the corruption measure, we select ICRG as the most consistent data source covering countries in our analysis. We also used two alternative corruption proxies.

First, we measure natural resource activity according to the natural resource rents available from the WBWDI database, which is similar to Bhattacharyya and Hodler (2009), who applied the log of resource rents per capita from the World Bank. Moreover, according to Poelhekke and van der Ploeg (2010), natural reserves may be reported when it is economically sound to exploit them, so the greatest investment activity may be found when the natural resource gains become more attractive; thus, the natural rents may be a good measure to exploit. On a more general level, the authors discussed the emerging importance of resource inclusion at the national accounting level despite the lack of available data and the differences between various resource data providers, such as the IMF, the UN, the WB and BP statistics.

Second, in our study, we preferred ICRG's corruption measure (concerned with financial corruption and excessive patronage, where a higher score of 6 implies a less corrupted environment versus the lowest 0 score for excessively corrupted settings) for the following reasons. The first reason concerns the quantity of data available for the countries in our sample. Therefore, we may be able to minimise the risk of sample selection bias and cover a reasonably wider time dimension. Second, this corruption proxy is used in a number of existing studies (see e.g., Asiedu and Lien, 2011; Poelhekke and van der Ploeg, 2010). We also used an alternative corruption quality through the ICRG's bureaucracy parameter to check the robustness of our results. In addition, similar to Bhattacharayya and Hodler (2009), we used the corruption perception index (CPI), which is publicly available from Transparency International. However, the latter CPI index's data is only available for 1995 onwards, whereas our research starts three years earlier, covering the period from 1992 to 2001.

Third, in order to test that the natural rent effect on FDI depends on institutional quality represented by corruption, we introduce the interaction term between the two.

Figure 5.1: FDI, natural resource rents and corruption, 1992–2001



There are four FDI inflow types provided by UNCTAD (primary, secondary, tertiary and other). We focus on the total FDI inflows and FDI into the primary sector (as mining, quarrying, petroleum exploration, other energy related) that are the ratios to GDP. General FDIs are made into the primary sector investments, the secondary sector (as major ones are food, forestry, metallurgy, machinery, light industry and others) and FDI into tertiary industry (construction, distribution, wholesale, telecoms etc.). There are FDI inflows in 'other' sectors, but these have fewer observations and do not clarify which sectors these cover. We use the period from 1992–2001 where the most primary FDI inflow observations are provided. A full description of measures can be found in Section 5.3 and the Tables within.

Figure 5.1 shows that the economic return for natural resource extraction is between 3 and 12 times the primary capital invested, and even higher in relation to overall investments. The returns on those natural rents have been constantly raised since 1998, whereas both primary and overall FDI inflows in the countries have reduced. Throughout the same time period, the corruption level has increased. This may indicate the importance of both natural resource rents and corruption existence in relation to the FDI investments.

Table 5.1 demonstrates that according to the descriptive statistics, the means of natural resource activity (the ratio of resource rents to GDP) for both the primary sector and total FDI are at around the same level of 8%, which is expected, considering that resource rents are concentrated in the primary sector. Moving to the corruption measure (ICRG), the higher mean value of this index indicated that investments in the primary sector were found to be less corrupted when compared to overall investments. This may show that there is a tighter control of corruption in regard to the primary sector.

Table 5.1: Means and standard deviations of selected FDI inflows, corruption, resource rents and additional variables, 1992–2001

Variables	FDI primary			FDI total		
	Obs	Mean	St Dev	Obs	Mean	St Dev
FDI inflows to GDP ratio						
FDI inflows by types	327	0.016	0.044	387	0.026	0.070
Natural resource rents and corruption						
Total natural resource rents/GDP	301	0.07	0.09	4,180	0.08	0.13
Ln of total natural resource rents/GDP	301	-3.78	1.70	4,180	-3.75	1.85
Corruption	321	3.66	1.63	2,142	3.01	1.69

The FDI inflows are separated into two types: FDI in the primary sector and total FDI (combined primary, tertiary, secondary and other). We introduce the ratios of FDI to GDP of a country (in constant 2005 money). The FDI inflows, in general, measure the international investment level, and its economic significance is widely discussed in the existing literature and is obtained from UNCTAD. The two selected FDI inflow ratios are described in Section 5.2. We apply the corruption index extracted from the ICRG database, where the highest score of 6 represents the least corrupted country and the 0 score is for the most corrupted countries. Following the World Bank (WBWDI), the total natural resource rent is defined by the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents and forest rents to the GDP ratio (we use the natural log of the ratio).

5.3.2. Control variables

We discuss control measures related to the literature reviewed in Section 4.2. These include trade openness (natural log of percentage of GDP), GDP per capita (natural log), level of credits obtained from banking institutions, military power in the state and the number of telephone lines per 100 citizens as a control for infrastructure. All the control parameters were obtained from the WB database, whereas the military in politics parameter is extracted from the ICRG.

Table 5.2: Means and standard deviations of selected control variables, 1992–2001

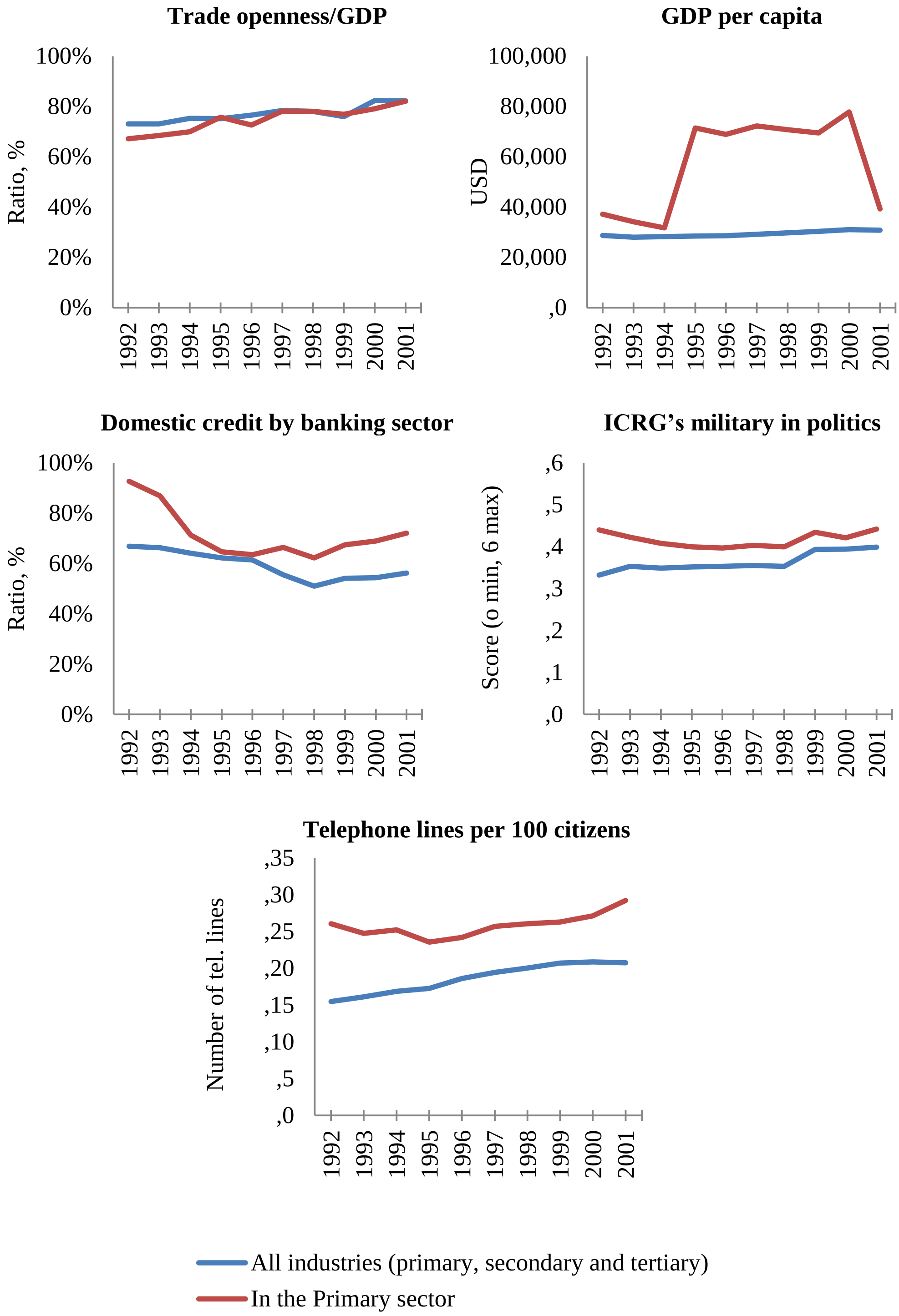
Variables	FDI primary			FDI total		
	Obs	Mean	St Dev	Obs	Mean	St Dev
Trade openness/GDP	304	0.75	0.44	3,888	0.73	0.41
Ln of trade openness/GDP	304	-0.43	0.53	3,888	-0.48	0.62
GDP per capita	299	57,345	188,189	2,924	30,866	135,115
Ln of GDP per capita	299	9.37	1.49	2,924	8.36	1.97
Credit by banking sector	304	0.72	0.48	3,468	0.56	0.62
Military in politics	321	4.24	1.84	2,142	3.44	2.14
Telephone lines per 100 citizens	320	26.95	23.05	5,240	12.77	18.18

We implement control variables as trade openness denoted through the natural log (the sum of exports and imports of goods and services measured as a share of gross domestic product). GDP per capita is based on purchasing power parity (PPP). PPP GDP is gross domestic product converted to international dollars using purchasing power parity rates. The data is in constant 2005 international dollars. The domestic credit provided by the banking sector includes all credit to various sectors on a gross basis, with the exception of credit to the central government, which is net. The military force measure may be used to control riots, public tensions and, more importantly, to provide the defence for the state budget at the expense of the budgeted allocations. Telephone lines per 100 citizens measures infrastructure development through the availability to communicate. All variables are obtained from the World Bank (WBWDI, but military force data is from the ICRG database.

The first measure selected, openness of trade, should favour capital inflows if there is a higher demand for goods and services and an increased income level in the country (Asiedu and Lien, 2011). Trade openness positively influences the economy and thereby attracts FDI inflows. The trade openness proxies two aspects: the quality of the country’s international trade regime and the propensity for international firms to export. Figure 5.2 and Table 4.2 show that the average trade openness to GDP ratio for total FDI investment stands at 73%, but in regard to primary investments, this ratio is a few per cent higher at 75%. The mean values indicate that countries in our sample may be attractive for international investors as they generate high export levels.

The second measure, domestic income, measured as GDP per capita, captures potential economies of scale. Various studies find that companies tend to invest more in the larger economies, where they can create new market opportunities (see e.g., Asiedu and Lien, 2011). According to other research, GDP per capita is also used as a control for the investment climate (Asiedu, 2002). Figure 5.2 and the descriptive statistics in Table 5.2 highlight that GDP per capita is almost twice as high in those resource-abundant countries compared to the overall investment levels. This may indicate that investments in resource-abundant countries may be especially important for economic wealth.

Figure 5.2: Country-level observations, 1992–2001



The graphs represent mean yearly measures of country level observations used in the estimations. A full description of selected measures can be found in Section 5.2, and Section 5.3 provides descriptive statistics for the measures. We use the period of 1992–2001, where the most primary FDI inflow observations are provided.

The last measure, availability of commercial loans, may play an important role in capital-intensive industries (Alfaro et al., 2004). That is, Figure 5.2 and Table 5.2 demonstrate that the credit obtained from a banking institution (the ratio of domestic credit by banking sector to GDP) stimulates primary sector investors to raise the required capital locally.

As we show in Section 5.2, capital-intensive industries that are supposed to provide high economic rents are likely found in corrupted business and state environments (Hausman and Rigobon, 2002; Acemoglu et al., 2004; Caselli and Cunningham, 2009). Thus, following ICRG, military force may be used to control riots, public tensions, and more importantly, to provide defence for the state budget at the expense of the budgeted allocations. For this reason, we control for the military power in the country using a related proxy from the ICRG, in which the maximum score of 6 indicates less military participation and a less politically risky environment, and the minimum score of 0 indicates a greater exposure of the military regime in the country. In Figure 5.2 and Table 5.2 the mean values of the military in politics indicate that comparatively less political tensions (higher scores indicate less tensions) are to be found in resource-abundant countries compared to overall military control over total FDI. This can indicate that revenues from natural resource exploration allow for institutions to promote the required political views to the masses and so less military interventions are required to control for possible tensions.

As another control measure, infrastructure facilities are well known to attract FDI and it is expected that we will see a significant positive relation between infrastructure and FDI, and it is expected to be similarly important for both resource-abundant and non-resource countries. For instance, Kinoshita and Campos (2010) used the number of landline telephone numbers as a proxy because they allow businesses to communicate. Others use the existence of utility services (water, electricity) or public transportation to proxy for infrastructure (see e.g., Asiedu, 2002). We also tried alternative measures such as a gross fixed capital formation to GDP ratio and the availability of roads, rail and ports, although we were unable to obtain enough data to perform these alternative estimations. Figure 5.2 and Table 5.2 demonstrate that, on average, significantly higher numbers of telephone lines are installed within primary industries compared to aggregate FDI.

5.4. Methodology

Our base model specifies FDI inflow type as a function of natural resource rents, corruption and the interaction between the two. We start with a pooled OLS estimation, and employ various specifications (OLS-RE, OLS-FE, OLS-FD, elasticity) as described in the theoretical background in Chapter 2. Then, we employ the GMM estimator because inclusion of the lagged dependent measure in the RHS of the equation may bias the OLS estimates, as the lagged dependent is correlated with country specific characteristics. The general regression is as follows (Table 5.3 for the energy sector and Appendix 5.A for total FDI inflows):

$$\text{FDI inflow type}_{it} = \gamma_1 \text{FDI inflow type}_{it-1} + \beta_2 \text{Nat.res.rents}_{it} + \beta_3 \text{Corruption}_{it} + \beta_4 (\text{Corruption*Nat.res.rents})_{it} + \alpha_i + u_{it} \qquad \text{Eq. (5.1)}$$

where

FDI inflow type_{it} = primary or total FDI inflow in the i-th country in year t,

t = 1992–2001,

α_i = the unobserved time-invariant country specific effects (fixed effects),

u_{it}= is a unique country’s error term.

Following the methodology from Chapter 2, we start with the ordinary pooled OLS estimation; however, we are aware that countries have individual characteristics which may or may not influence regressors. Therefore, the OLS regression may be biased because unobserved time-invariant country effects may be correlated with regressors. We address the issue by employing the fixed effects option (OLS-FE), which allows us to control for unobserved characteristics within countries. That is, the error term, $e_{it,}$ will consist of α_i, the unobserved country specific effects, and u_{it}, the observation-specific errors ($e_{it}= \alpha_i + u_{it}$). Additionally, we present the estimates for OLS-RE and the Hausman test for the validity of either random or fixed effects selection (if there is a correlation between the individual and/or the time effects and the independent variables imposed, the OLS-FE may be suggested to mitigate the endogeneity issue). Further, we illustrate the OLS-FD model and discussion for elasticities to be in line with the theoretical background of panel data analysis.

In the next step, we developed our model to capture the effect of lagged FDI on current FDI inflows. We did this because previous FDI activity may enhance current FDI inflows. That is the reason for including the 'FDI inflow $type_{it-1}$' on the RHS of the equation above. The presence of the lagged dependent variable 'FDI inflow $type_{it-1}$' creates dynamic panel bias, causing the correlation between the explanatory and error term, $e_{it-1,}$ which is a function of the time-invariant country specific fixed effects, α_i. The detailed procedure of the GMM estimator implementation is described in Chapter 2. The lagged dependent variables (FDI inflow types) are treated as endogenous, and the independent variables are treated as strictly exogenous (corruption, natural rents, the interaction term of natural rents and corruption and a set of control measures). The GMM estimator used the second lag of the endogenous variable. We utilize only internal instruments; we do not include additional external instruments (similarly to Asiedu and Lien's 2011 study on the democracy effect for FDI). The weak instruments test is reported through F-statistics. Further, the Sargan test for over-identifying restrictions is not reported because we do not have additional external instruments.

In order to identify the net effect of regressors, we introduce additional control measures that are likely to impact dependent FDI inflows. Tables 5.4 (for the energy sector) and Appendix 5.A (for all industries) demonstrate estimates for the inclusion of control measures:

$$\text{FDI inflow type}_{it} = \gamma_1\text{FDI inflow type}_{it-1} + \beta_2\text{Nat.res.rents}_{it} + \beta_3\text{Corruption}_{it} + \beta_4(\text{Corruption*Nat.res.rents})_{it} + \beta_z Z_{it} + \alpha_i + u_{it} \quad \text{Eq. (5.2)}$$

where

equation indexes are as per Eq. (4.1),

Z_{it} = Trade $openness_{it}$, GDP per $capita_{it}$, Loans from $banks_{it}$, Military $power_{it}$, Telephone $lines_{it}$.

On a general level, we have focused on the years with the most observations for FDI inflows and explanatory variables, which are from 1992 to 2001. We compare primary FDI inflow estimates with the total FDI inflows. We present the results for Eq. (4.1) and (4.2) in Tables 5.3 and 5.4 for primary FDI inflows but total FDI inflow estimates are located in Appendix 5.A. Finally, we included a set of time dummies (1992–2001) to see whether unexpected variation (special events) may affect the dependent FDI inflow type variables. Our empirical analysis focuses on the size, sign and significance of the estimated coefficients and the elasticity.

5.5. Results

In this section, the natural resource rents and corruption effects on FDI are empirically evaluated after controlling for additional measures. The dependent variable is the FDI inflows to GDP ratio (primary and total). The explanatory variables are the natural resource rents to GDP ratio, and the corruption index is provided by the ICRG, the lag of dependent FDI and the set of additional control variables: trade openness to GDP, GDP per capita, credits provided by the banking sector, the military in politics and the number of telephone lines as an infrastructure proxy.

5.5.1. Panel estimates of FDI investments (hypotheses tests), 1992–2001

In the hypotheses development section, we showed that the natural resource exploration effect is likely to concentrate on primary investments, but with no significant exposure on overall country FDI. This is because each investment type is targeted by specific investor interests such as market or business potential, returns' expectations, stability or the development of the country, and industry demand for the products created etc. In particular, Dunning's OLI paradigm states that the natural resource sector would expect to attract greater capital investments because of higher economic added value and investment returns in a relatively shorter time period in comparison to other industries (Dunning, 1980). In addition, the business conditions would be an imperative element where institutional regulation of the industry is of importance.

In our results, we find broad evidence of natural resource investment concentration in the primary industry (refer to Table 5.3 and Appendix Table 5.A.1). Similarly, the findings indicate that the institutional environment, measured by the corruption index, is an important regulatory element in investment decision making. More significantly, the results suggest that there is much to be done in order to balance the negative effect of corruption, despite the high income potential of primary investments, whilst natural resource economics is a driving factor and the corruption is a significant proxy for business regulatory power. The results also suggest that previous period-specific FDI inflows are not an important element for the current primary investments, but adversely influence the countries' aggregate FDI inflows. The negative effect of previous-year FDI may indicate that investors, in general, are rather more interested in the selection of new opportunities than in continuing in the present markets.

Although all regression results are in line with the hypotheses tested, there are caveats, which we need to be aware of whilst discussing the empirical findings. At first, the current literature's empirical evidence is rather limited, despite the theoretical framework of the OLI paradigm. That is, most of the existing studies refer to the effect of natural resource exploitation and the corruption effect on economic development. In those studies, where the natural resource and corruption impact on FDI is highlighted, the results often discuss the country level aggregated FDI inflows, but more notably, there is no interaction effect documented between the two variables for capital-investment activity. Therefore, although we can rely on the suggested results as value being added to the existing literature, our study should be considered as exploratory. Second, country selection is limited, as many of these do not possess a good set of consistent variables, and consequently, we have to operate with missing observations. Thus, the important occurrences may not be observed due to data unavailability issues. Third, although we control for the additional regressors (refer to the further results discussion), the variety of additional effects may apply to different countries. That is, to some extent we rely on the presumption that the selected countries may be affected to a common degree by the same explanatory and control variables.

From the theoretical model specification, we have operated with different OLS specifications (Chapter 2 refers to the detailed discussion). The employed model and the post-estimation techniques indicate the likely validity of the empirical results. The joint significance test suggests the importance of selected explanatory variables. However, the years test rejects the null hypothesis that years coefficients are equal to zero, implying that no control for time effects is needed. This can be expected, as the investors are rather driven by specific interests and accessibility to the investment returns but not to various timing effects. Furthermore, the Hausman test demonstrates that OLS with fixed effects is a preferred estimation methodology. As the lagged dependent is included among the regressors, we undertake the weak instruments test, which indicates that there is no correlation between endogenous regressors and the excluded instruments (Baum et al., 2007). We do not show the Sargan test for over-identifying restrictions, as no additional external instruments are included. We are not aware of the related FDI studies which implemented external instruments (for instance, Asiedu and Lien (2011) state that they do not consider external instruments without giving the reasons for). The future analysis shall concentrate on the potential inclusion of external instruments in order to improve the understanding of the FDI analysis.

The results of the hypotheses testing and post-estimation techniques indicate that there are other factors which may expected to reflect on FDI decision making. From this

Table 5.3: Panel estimates of primary FDI investments (hypotheses tests), 1992–2001

	Pooled OLS (without years control) 1	Pooled OLS 2	OLS-RE 3	OLS-FE 4	First difference (robust clustered) 5	GMM (inclusion of lagged dependent) 6
H1: Greater access to natural resources may promote inward FDI in the primary sector						
Nat. rents/GDP	**0.00359***	**0.00391***	**0.00391***	**0.00283***	0.000328	**0.00311***
	(0.00223)	(0.00237)	(0.00228)	(0.00255)	(0.00270)	(0.00305)
FDI inflows type/GDP						0.175
						(0.206)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.0325****	0.131	0.131	0.161	0.0708	
	(0.0154)	(0.293)	(1.223)	(1.227)	(0.0990)	
Observations	299	299	299	299	266	235
Number of companies	32	32	32	32	32	30
Joint test	0.1080	0.0983	0.0859	0.2669	0.9033	0.5817
Years test		0.2302	0.2807	0.3061		0.2618
Hausman test				1.33		
Weak instruments						0.0232
H2: Greater corruption may increase or decrease inward FDI in the primary sector						
Corruption	-0.00279	-0.00293	**-0.00293****	**-0.00267****	-0.000633	**-0.00689***
	(0.00207)	(0.00220)	(0.00120)	(0.00123)	(0.00289)	(0.00688)
FDI inflows type/GDP						0.150
						(0.205)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.0274****	0.383	0.383	0.365	0.105	
	(0.0137)	(0.325)	(1.073)	(1.057)	(0.257)	
Observations	321	321	321	321	286	251
Number of companies	34	34	34	34	34	32
Joint test	0.1774	0.1817	0.0147	0.0306	0.8269	0.5966
Years test		0.2375	0.2954	0.2861		0.2714
Hausman test				1.0000		
Weak instruments						0.0284
H3: The effect of natural resources on primary FDI depends on the extent of corruption in the country						
Nat. rents/GDP	**0.0125***	**0.0125****	**0.0125*****	**0.0123*****	0.00518	0.0207
	(0.00652)	(0.00636)	(0.00343)	(0.00370)	(0.00723)	(0.0123)
Corruption	**-0.0122***	**-0.0121***	**-0.0121*****	**-0.0123*****	-0.00611	-0.0257
	(0.00694)	(0.00699)	(0.00306)	(0.00317)	(0.0102)	(0.0152)
Corruption* Nat. rents/GDP	**-0.00231***	**-0.00225***	**-0.00225*****	**-0.00228*****	-0.00124	**-0.00507***
	(0.00125)	(0.00124)	(0.000681)	(0.000699)	(0.00174)	(0.00284)
FDI inflows type/GDP						0.101
						(0.197)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.0755****	0.0686	0.0686	0.0807	-0.0631	
	(0.0369)	(0.336)	(1.176)	(1.188)	(0.197)	
Observations	294	294	294	294	262	231
Number of companies	31	31	31	31	31	29
Joint test	0.2810	0.2696	0.0002	0.0009	0.8612	0.5163
Years test		0.3133	0.2395	0.2654		0.7196
Hausman test				0.9600		
Weak instruments						0.0500

Note: White's standard errors are applied to control for heteroscedasticity.

The table above shows the three hypotheses we test, which are the effect of natural resource activity (H1), corruption (H2) and the effects of their interaction (H3) on selected FDI inflows. The dependent variable is FDI primary inflows to GDP. Explanatory variables are presented in the relevant section. The estimation specification follows the theoretical background as of Chapter 2. Legends (*) to the right of the coefficients represent the significance levels (*** $p<0.01$, ** $p<0.05$, * $p<0.1$) and standard errors are shown in parentheses.

perspective, we continue with the examination of natural resource rents and the corruption effect on FDI with additional selected variables.

5.5.2. Panel data estimates with additional control variables, 1992–2001

The estimates of additional control variables suggest their importance for both primary and total FDI inflows (Table 5.4 and Appendix 5.A). In line with the existing literature, the control for trade openness and credit availability indicates a positive and significant effect on FDI attraction. In contrast, the low economic development, lack of infrastructure and previous FDI engagement distort capital investments. Further, the control for the military in politics index suggests that investments in natural resources exploitation are positively affected by the presence of the forces. This is because the military is commanded to control and mitigate tensions when confronted with high economic returns within natural resource-abundant countries. These findings are in line with Hausman and Rigobon (2002), Acemoglu et al. (2004) and Caselli and Cunningham (2009).

The elasticity results demonstrate the proportionate changes in the two qualitatively different variables, which are measured in two different types of units, allowing for the comparison of quantitative changes between the two. Table 5.5 shows the sensitivity relationship between primary FDI inflows and the changes in the explanatory variables. Both corruption, economic development (as GDP) and the trade openness are elastic towards FDI levels. For instance, a sensitivity measure of −2.79 (for OLS-FE) means that the percentage change in the quantity of FDI is almost three times the percentage change in corruption. The negative sign indicates the adverse effect in terms of primary FDI attractiveness. In contrast, elasticity in regards to the trade openness means that a 1% change in trade openness will lead to a 1.02% to 1.59% change in the primary FDI inflows. The elasticity of these measures in terms of primary FDI suggests that these are important, but are not of as much importance as inelastic natural rents, corruption and the natural rent interaction term, the military in politics, credit availability and infrastructure.

In regards to post-estimation evaluation, the statistical tests are in line with the general findings, and indicate the significance of the included variables (joint test) but reject the importance of the time effects. The Hausman test suggests that OLS-FE is a preferred model specification, whilst the weak instruments test indicates that there is no correlation between endogenous regressors and the excluded instruments when dynamic model specification is considered.

Table 5.4: Panel data estimates of primary FDI inflows: Including control variables, 1992–2001

	Pooled OLS (without years control) 1	Pooled OLS 2	OLS-RE 3	OLS-FE 4	First difference (robust clustered) 5	GMM (inclusion of lagged dependent) 6
Nat. rents/GDP	0.0101 (0.00648)	**0.0102*** (0.00591)	**0.0102**** (0.00404)	**0.0119**** (0.00527)	0.00149 (0.0124)	**0.0277***** (0.00988)
Corruption	-0.0120 (0.00842)	-0.0118 (0.00806)	**-0.0118***** (0.00356)	**-0.0122***** (0.00390)	-0.00750 (0.0120)	**-0.0315***** (0.0108)
Corruption* Nat. rents/GDP	**-0.00229*** (0.00136)	**-0.00214*** (0.00127)	**-0.00214***** (0.000709)	**-0.00233***** (0.000750)	-0.00114 (0.00180)	**-0.00600***** (0.00190)
Trade openness/GDP	**0.0217***** (0.00835)	**0.0340***** (0.0109)	**0.0340***** (0.00704)	**0.0266***** (0.00892)	0.0301 (0.0238)	**0.0331**** (0.0150)
GDP per capita	**-0.0119***** (0.00461)	**-0.0116***** (0.00409)	**-0.0116***** (0.00389)	-0.0129 (0.0197)	-0.0269 (0.0429)	-0.0713 (0.0419)
Credit by banking sector	**0.0220**** (0.0109)	**0.0184*** (0.0102)	**0.0184***** (0.00461)	**0.0132***** (0.00505)	0.00805 (0.00772)	0.0179 (0.0164)
Military in politics	0.00182 (0.00231)	0.00216 (0.00227)	0.00216 (0.00149)	**0.000924*** (0.00152)	0.00262 (0.00305)	**0.00759*** (0.00413)
Tel. lines per 100 citizens	**-0.000459**** (0.000187)	-0.000168 (0.000154)	-0.000168 (0.000241)	0.000235 (0.000403)	0.000694 (0.000551)	**0.00168*** (0.000831)
FDI inflows type/GDP						0.0620 (0.191)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.173***** (0.0596)	**1.913**** (0.847)	1.913 (1.289)	1.705 (1.378)	-0.285 (0.454)	
Observations						
Number of companies	273	273	273	273	241	213
Joint test	0.0335	0.0279	0.0000	0.0000	0.0721	0.1158
Years test		0.3660	0.1670	0.4616		0.3075
Hausman test				0.0000		
Weak instruments						0.0000

Note: White's standard errors are applied to control for heteroscedasticity.

The table above shows the three hypotheses we test with the inclusion of control measures. Respectively, this table is a continuation of Table 5.3, which tests the effect of natural resource activity (H1), corruption (H2) and the effects of their interaction (H3) on selected FDI inflows. The dependent variable is FDI primary inflows to GDP. Explanatory variables are presented in the relevant section. The estimation specification follows the theoretical background as in Chapter 2. Legends (*) to the right of the coefficients represent the significance levels (*** p<0.01, ** p<0.05, * p<0.1) and standard errors are shown in parentheses.

Table 5.5: Panel data estimates of primary FDI inflows: As elasticity including control variables, 1992–2001

	Pooled OLS (without years control) 1	Pooled OLS 2	OLS-RE 3	OLS-FE 4	First difference (robust clustered) 5	GMM (inclusion of lagged dependent) 6
Nat. rents/GDP	0.04	0.04	0.04	0.05	0.01	0.12
Corruption	-2.75	-2.70	-2.70	-2.79	-1.72	-7.21
Corruption* Nat. rents/GDP	-0.04	-0.03	-0.03	-0.04	-0.02	-0.10
Trade openness/GDP	1.02	1.59	1.59	1.25	1.41	1.55
GDP per capita	-6.97	-6.79	-6.79	-7.55	-15.75	-41.76
Credit by banking sector	0.99	0.83	0.83	0.59	0.36	0.81
Military in politics	0.48	0.57	0.57	0.24	0.69	2.01
Tel. lines per 100 citizens	-0.77	-0.28	-0.28	0.40	1.17	2.83
FDI inflow type/GDP						0.06

This table continues from Tables 5.4 by presenting the elasticity for the energy sector and two subsectors. The elasticity defines the percentage change in the dependent variable for a one per cent change in the explanatory variable. The mathematical presentation is 'Elasticity = Estimated explanatory coefficient * (Mean explanatory measure/Mean dependent measure)'. Chapter 2 provides a detailed explanation on elasticity. For instance, in the GMM application, a 'Nat. rents/GDP' elasticity of 0.12 means that, on average, for a 1% increase in natural rents to GDP ratio, the primary FDI would increase by 0.12%. (Elasticity = 0.0277*(0.0700/0.0160) = 0.12, where the explanatory coefficient is from Table 5.4, and the mean measures are from Table 5.1 and Table 5.2.)

5.6. Concluding comments

In this chapter, we investigated the effect of natural resource activity (natural resource rents) and corruption (financial corruption and excessive patronage) on FDI inflows in the primary and overall sector (the ratio of FDI to GDP). The analysis presented is of an exploratory investigation of FDI decision making. The estimations provided results for 133 countries where FDI data and explanatory data were available for the period from 1992–2001. For the estimation, we have used OLS specifications and also the GMM estimator to control for the dynamic nature when the lagged dependent is included among the explanatory variables. Our theoretical predictions (hypotheses) are supported by the empirical estimations.

The results are pertinent for the primary sector, where FDI inflows are associated with the natural resource activity depending on the extent of corruption. Our results hold after controlling for other measures known to influence FDI investments such as trade openness (natural log of % of GDP), GDP per capita (natural log), level of credits obtained from banking institutions, the military power in the state and the number of telephone lines per 100 citizens as a control for infrastructure.

The findings imply FDI investments are driven by specific interests. That is, no significant effect for natural resource exploitation has been found in regards to overall country FDI. Although other common control variables such as trade openness, GDP, credit availability, the military in politics and infrastructure are of importance for both FDI inflows.

The results suggest that the significance of natural resource activity depends on corruption, and therefore the presence of corruption significantly alters the relationship between natural rents and FDI inflows:

- Essentially, we explain how corruption is used as a proxy of the institutional environment. In this way, corruption can either distract or attract investment inflows depending on its level. Corruption may raise the cost of foreign investments, since investors have to pay bribes and bear extra contract risks; but at the same time, corruption allows for the profits to stay with investors, and for governments to provide a high income source.

Second, we find that corruption significantly reduced the attraction of natural resource rents applied to primary FDI investments, but with no significant effect on the overall FDI inflows:

- It is very likely that the resulting potential economic benefits from natural resource abundance both influence and are influenced by the institutional environment. That is, if institutions are working towards country growth through economic gains from primary industries being distributed for the development of other industries, then these gains will not remain within the primary sector.

Thus, it is important to find the factors within the institutional environment that would allow for natural resource rents to promote overall capital investments in the countries. In addition, future work needs to acquire much more sophisticated data samples to provide supplementary robustness to the results, and to concentrate on specific geographical locations so as to be able to unmask potential country specific variances which may impact FDI decisions differently. We aim to continue the natural resource and institutional environment relationship investigation in terms of FDI in the proposed direction.

Appendix 5.A: Detailed regression estimates for various controls

Table 5.A.1: Panel data estimates of total FDI inflows: (Hypotheses tests), 1992–2001

	Pooled OLS (without years control) 1	Pooled OLS 2	OLS-RE 3	OLS-FE 4	First difference (robust clustered) 5	GMM (inclusion of lagged dependent) 6
H1: Greater access to natural resources may promote inward FDI in the total sector						
Nat. rents/GDP	0.00322 (0.00354)	0.00415 (0.00346)	0.00415 (0.00396)	0.00178 (0.00512)	**-0.0176**** (0.00802)	0.00589 (0.00820)
FDI inflows type/GDP						**-0.450**** (0.192)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.0445*** (0.0233)	0.829 (0.853)	0.829 (2.524)	0.922 (2.542)	-0.781 (0.559)	
Observations	362	362	362	362	324	288
Number of companies	38	38	38	38	38	37
Joint test	0.3632	0.2301	0.2950	0.7781	0.0278	0.0173
Years test		0.1669	0.1531	0.1885		0.5712
Hausman test				1.0000		
Weak instruments						0.0000
H2: Greater corruption may increase or decrease inward FDI in the total sector						
Corruption	0.00171 (0.00353)	0.00154 (0.00381)	0.00154 (0.00232)	0.00259 (0.00244)	0.00621 (0.00631)	0.000838 (0.00407)
FDI inflows type/GDP						**-0.433*** (0.223)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	0.0208 (0.0224)	1.289 (0.904)	1.289 (2.262)	1.219 (2.260)	-1.127 (0.941)	
Observations	359	359	359	359	322	285
Number of companies	37	37	37	37	37	36
Joint test	0.6269	0.6869	0.5075	0.2886	0.3246	0.0015
Years test		0.2479	0.1778	0.1893		0.5464
Hausman test				0.2000		
Weak instruments						0.0000
H3: The effect of natural resources on total FDI depends on the extent of corruption in the country						
Nat. rents/GDP	-0.00183 (0.0112)	-0.00308 (0.0107)	-0.00308 (0.00636)	-0.00757 (0.00730)	**-0.0444**** (0.0223)	-0.0125 (0.00856)
Corruption	0.00888 (0.0139)	0.0119 (0.0139)	**0.0119*** (0.00629)	**0.0141**** (0.00667)	0.0421 (0.0278)	0.0184 (0.0140)
Corruption* Nat. rents/GDP	0.00163 (0.00241)	0.00239 (0.00236)	**0.00239*** (0.00135)	**0.00268*** (0.00141)	0.00817 (0.00510)	0.00462 (0.00283)
FDI inflows type/GDP						**-0.431*** (0.218)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	0.0140 (0.0656)	0.859 (0.943)	0.859 (2.461)	0.989 (2.477)	0.0585 (0.950)	
Observations	335	335	335	335	300	266
Number of companies	35	35	35	35	35	34
Joint test	0.1719	0.0565	0.1556	0.1938	0.1893	0.0008
Years test		0.1824	0.0953	0.1299		0.7841
Hausman test				0.9999		
Weak instruments						0.0000

Note: White's standard errors are applied to control for heteroscedasticity.

The table shows the three hypotheses we test with the inclusion of control measures. Respectively, this table is a continuation of Table 5.4, which is the effect of natural resource activity (H1), corruption (H2) and the effects of their interaction (H3) on selected FDI inflows. The dependent variable is FDI total inflows to GDP. Explanatory variables are presented in the related section. The estimation specification follows the theoretical background as in Chapter 2. Legends (*) to the right of the coefficients represent the significance levels (*** p<0.01, ** p<0.05, * p<0.1) and standard errors are shown in parentheses.

Table 5.A.2: Panel data estimates of total FDI inflows: Including control variables, 1992–2001

	Pooled OLS (without years control)	Pooled OLS	OLS-RE	OLS-FE	First difference (robust clustered)	GMM (inclusion of lagged dependent)
	1	2	3	4	5	6
Nat. rents/GDP	-0.00677 (0.0111)	-0.00553 (0.0102)	-0.00553 (0.00691)	-0.0109 (0.0104)	**-0.0671*** (0.0354)	-0.0128 (0.0195)
Corruption	0.0162 (0.0171)	0.0159 (0.0163)	**0.0159**** (0.00715)	**0.0234***** (0.00844)	0.0590 (0.0367)	**0.0323*** (0.0162)
Corruption* Nat. rents/GDP	0.00207 (0.00267)	0.00246 (0.00241)	**0.00246*** (0.00138)	**0.00336**** (0.00159)	**0.00937*** (0.00566)	**0.00542*** (0.00293)
Trade openness/GDP	**0.0387**** (0.0189)	**0.0462**** (0.0215)	**0.0462***** (0.0125)	0.00700 (0.0195)	0.0766 (0.0631)	0.0344 (0.0320)
GDP per capita	**-0.0200**** (0.00906)	**-0.0196**** (0.00829)	**-0.0196***** (0.00619)	0.0130 (0.0367)	0.00321 (0.166)	-0.0255 (0.0662)
Credit by banking sector	0.0379 (0.0317)	0.0382 (0.0281)	**0.0382***** (0.00946)	**0.0313***** (0.0111)	0.0317 (0.0329)	0.0425 (0.0265)
Military in politics	-0.00356 (0.00490)	-0.00156 (0.00502)	-0.00156 (0.00308)	**-0.00711**** (0.00331)	-0.0131 (0.0101)	**-0.00854**** (0.00390)
Tel. lines per 100 citizens	**-0.000967**** (0.000443)	**-0.000792**** (0.000322)	**-0.000792**** (0.000397)	-0.000202 (0.000863)	-6.40e-06 (0.00150)	0.00194 (0.00187)
FDI inflows type/GDP						**-0.435**** (0.196)
Year dummies	No	Yes	Yes	Yes	No	Yes
Constant	**0.189*** (0.114)	2.164 (1.817)	2.164 (2.725)	1.505 (2.918)	1.037 (1.712)	
Observations	314	314	314	314	279	248
Number of companies	33	33	33	33	32	32
Joint test	0.0004	0.0008	0.0000	0.0299	0.7968	0.0000
Years test		0.2929	0.1103	0.2446		0.2891
Hausman test						
Weak instruments				0.0038		0.0000

Note: White's standard errors are applied to control for heteroscedasticity.

Respectively, this table is a continuation of Table 5.4, which presents the effect of natural resource activity (H1), corruption (H2) and the effects of their interaction (H3) on selected FDI inflows with the inclusion of control measures. The dependent variable is FDI total inflows to GDP. Explanatory variables are presented in the related section. The estimation specification follows the theoretical background as in Chapter 2. Legends (*) to the right of the coefficients represent the significance levels (*** p<0.01, ** p<0.05, * p<0.1) and standard errors are shown in parentheses.

CHAPTER 6

6. Conclusions

As the study comes to an end, we provide a summary, the contributions of our research, and the challenges we faced through the course of the dissertation. As such, this chapter consists of three sections. In Section 6.1, we introduce the summary of the findings; in Section 6.2, we provide an analysis of the research contributions; and, in Section 6.3, we discuss the shortcoming and challenges we faced, including the scope for further research.

6.1. Summary of findings

In this dissertation, we studied the implications of financing, CG, natural resource rents, and corruption for innovations, firm value, and FDI inflows in the energy industry. There are three empirical chapters.

Chapter 3

The first empirical chapter investigated financing for R&D in European energy companies. The central hypothesis we tested is that a lower leverage level corresponds to higher R&D in energy companies, as firms that are highly leveraged would be required to pay off greater borrowing costs from future growth opportunities generated by the R&D, with high outcome uncertainty. Energy companies are more likely to find investment support for R&D activities when their liabilities are not financially overburdened. Furthermore, we found support for the second hypothesis, that operating income has to be used to boost the necessary financing for R&D. Using firm-level data of more than 250 companies, available from OSIRIS for the years 1995–2007, we found support for the two hypotheses, after controlling for other factors.

The findings, however, highlighted that additional factors are key in attracting financing for innovations in both utilities and in oil and gas companies. In particular, we found that firm age positively affects the access for financing. That is, ‘younger’ companies are more likely to rely on operating income to boost the financing of R&D activities, because lending institutions consider firm age as a proxy of economic credibility and experience. Further, energy companies located in countries that have recently joined the EU lack access to financing for R&D when compared to rival firms within established EU member countries.

In future research, we aim to examine the differences in the factors for R&D between utilities and the oil and gas sector, which should contribute to sustained improvement of innovation activities in the common EU energy area.

Chapter 4

In the second empirical chapter, we explored the net effect of the introduction of CG codes in Russia, with special reference to T&D as an important element affecting the attraction of potential investors. The hypothesis we examined here is whether the introduction of T&D in this type of investment climate can necessarily boost firm value. While the introduction of T&D rules (and overall CG codes) can resolve the conflict of interest between the controlling and minority owners, the transparency of businesses may make them easy targets for aggressive competitors. The data on T&D measures was obtained from S&P's for the years 2003–2007 for the largest listed companies with cumulative market capitalisation of 90% of the Russian Stock Market in 2007. Firm-level data was obtained from the OSIRIS database, predominantly for the 2000–2008 period.

The results highlighted that the introduction of T&D has been met with limited success, especially for the oil and gas sector, perhaps because it initiated a conflict of interest between the controlling owners and the state. The latter has been highlighted by the moral hazard of revealing too much information, as Russian state agencies tend to prey on the more successful firms. In future research, we aim to determine how foreign multinational investments can resolve the conflict of interest between the state and the controlling owners, thus contributing to sustained improvement in firm value in Russia.

Chapter 5

In the final empirical chapter, we examined whether and how the introduction of natural resource activity and the existence of corruption determine primary FDI inflows. We followed the argument, from existing literature, that FDI depends on the existence of corruption, thereby allowing investors to protect their returns and governments' natural resource gains to provide an important budgeting source. We established three hypotheses to examine whether the extent of institutional mechanisms, measured by corruption, may or may not lead to lower or higher primary FDI investments, which are attracted due to natural resource rents. The existing literature provided mixed results, and whether both natural resource endowment and corruption have an impact on primary FDI is unclear.

In our analysis, we focused on a panel of 133 countries concerned with natural resource abundance, with FDI data from 1992 to 2001. Our main FDI source was the UNCTAD dataset, where natural resource rents are from the WB and where corruption is measured using the ICRG's proxy.

We found evidence of the persistent negative effect of corruption on the attraction of primary FDI activities in countries abundant in natural resources, even after controlling for other factors. We explain this as the corruption effect being twofold: on the one hand, its existence eases the investment access to primary sources, but on the other hand, it weakens FDI, as investors are prone to having to pay extra bribes and take greater contractual risks. Nevertheless, the economic gains from natural resource exploitation still attract greater investment attention.

Thus, it is vital to find ways of easing the negative effects of corruption in terms of the attraction of natural resource rents and promoting FDI investments in the primary industries. In future research, we aim to investigate corruption-related issues as they relate to primary FDI.

6.2. Dissertation contributions

Our empirical studies highlighted the important role of financing arrangements for R&D implementation in European Union energy companies; CG implementation towards firm value and investor attractiveness in Russian energy firms; and the interrelationship between corruption and natural resource activity as they affect primary FDI attraction in resource-endowed countries. Focusing on three energy sector interrelated analyses, we demonstrated the importance of further institutional and firm-level developments and policies in sustained energy industry development. We hope that dissemination of such findings will facilitate further discussion and stimulate future research in the energy area. In particular, the main contributions are as follows:

- Investigation of the effects of financing for innovations in the European energy sector led to an advanced understanding of the leverage effect: lower financing promoted R&D, while higher financial liabilities disadvantaged innovation activities in the important energy sector amid sustainable development and energy security concerns.

- Regarding the dependence of the European energy sector on Russian energy supplies, we examined the effect of the introduction of CG mechanisms on Russian energy firms. The study results highlighted the importance of the integrity of the general mechanism and the mere introduction of information T&D as pertaining to firm value, which aims to facilitate the attraction of additional investments.
- Examination of the main factors – natural resource abundance and the existence of corruption – for global energy, capital-investment attraction highlighted the importance of corruption control in host countries (those attracting FDI for the primary sector). This research led to an understanding of the extent of corruption in resource-abundant countries.

6.3. Challenges, shortcomings and future research

In the empirical analyses, we were faced with two main challenges. The first challenge was data availability and data sources. Second, we were limited by selected measures, especially for CG and FDI studies.

In the first two empirical chapters (Chapter 3 and Chapter 4), we used comprehensive firm-level data on balance sheets and cash flows from the OSIRIS database. We faced challenges in compiling the data on ownership structure and the nature of business descriptions (e.g., definitions of ownership type – privately owned, state owned etc. – are broad, mainly because of complicated definitions; business area identification can be assigned using a variety of business classifications, which may place the same company under different business categories). In order to mitigate inaccuracies in ownership definition, we contacted OSIRIS for clarification of the definitions; for industry classification, we selected the classifications with the most observations for our sample and checked them against the industry descriptions provided by the companies themselves (mainly from their websites).

For the second challenge, the limited availability of measures, which we employed in the second and third empirical chapters (Chapters 4 and 5), we were able to overcome the problem by extending estimation testing for the robustness and validity of the main hypotheses. Regarding the effect of the introduction of CG in Russia, we were able to obtain T&D parameters for the largest energy and non-energy companies, and further distinguished between the two main energy sectors: utilities and oil and gas producers. However, the T&D index was introduced in 2002, and only five scores for each company are available (on a year-to-year basis). Furthermore, T&D is the only consistent measure, and control for alternative CG measures is not an option. To test for the robustness of the T&D results, we controlled for the introduction of general CG by using dummy years, and we studied the slope and intercept effects of CG with each of the included explanatory and control measures in the estimations. Turning to the empirical analysis on FDI attractiveness for the primary sector, we had to concentrate on natural resource activity, measured though the ratio of natural resource rents to GDP. Although this measure has been used in other studies, we were limited by the alternative resource activity proxies. To ensure the robustness of the results, we estimated the net effect of both natural rents and corruption measures on FDI, and controlled for the interaction effect between the two; then, we included controls for additional factors likely to impact FDI decisions; and lastly, we introduced alternative estimation methodologies. In all three empirical chapters, we adopted a panel data methodology that minimises estimation bias due to omitted factors, and our results were robust to the alternative samples and methodologies considered.

We believe that future research needs, highlighted in Section 6.1, will address the gaps and challenges we faced in the current dissertation.

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