Production Characteristics, Financial Flexibility, and Capital Structure Decisions[☆]

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Abstract

This article reveals a positive and causal relationship between production flexibility and financial leverage. A worldwide sample of energy utilities allows us to apply three direct measures for production flexibility which are based on the technologies of the firms' power plants. For identification, we exploit privatizations and deregulations of electricity markets, gas and electricity prices, and geographical variations of natural resources as plausibly exogenous instruments. Variation in countries' investor protection and abnormal returns around the collapse of Lehman Brothers indicate a substitution effect between production and financial flexibility. Lastly, we find that the effect of production flexibility increases with electricity price volatility.

Keywords: Capital structure, leverage, production flexibility, financial flexibility, energy utilities

JEL: G30, G32

[☆] We thank Ralf Elsas, Markus Glaser, Christoph Kaserer, Olga Kuzmina, Klaus Mayer, Daniel Urban, Jan Zimmermann, and participants of the 2012 International Paris Finance Meeting, the 2013 Munich Finance Seminar, the 2013 Annual Conference of the Swiss Society for Financial Market Research (SGF), and the 2013 Annual VHB Meeting for their helpful comments and suggestions. The usual caveat applies.

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December 19, 2013

1. Introduction

This paper analyzes the relationship between production flexibility—as one dimension of a firm's operating flexibility—and financial leverage. The theoretical model of Mauer and Triantis (1994) predicts that firms with higher production flexibility choose higher leverage ratios because they can avoid operating losses by shutting down production facilities. Thus, the present value of their future operating cashflows is higher. Additionally, higher production flexibility reduces the volatility of the firm value. As a consequence, debt capacity and leverage increase. Thereby higher production flexibility also leads to a higher value of the interest tax shield. This positive effect is, however, more pronounced if financial flexibility is low (i.e, recapitalization cost are high). We empirically test these predictions based on three direct measures for production flexibility.

The construction of these direct measures is possible because we focus on energy utilities. In a first step, detailed data on all power plants around the globe between 2002 and 2009 are obtained from the Platts World Electric Power Plants (WEPP) database. A manual matching to listed energy utilities leads to the final sample including more than 30,000 power plants, which account for about 50% of the world's electricity production capacity.We then construct three measures of production flexibility: average run-up time, ramp-up cost, and full-load hours. These are based on the production technologies of the firms' different power plants. For example, gas fired power plants have higher production flexibility as nuclear or coal power plants.[1] Because energy utilities produce and sell mainly one product, i.e., electricity, their flexibility with regard to electricity generation is a reliable measure of their overall level of production flexibility.

Prior empirical literature on production flexibility mainly focus on indirect measures. In the context of capital structure, MacKay (2003) is the first to provide empirical evidence. He studies firms from different industries and finds a negative relationship between production flexibility and leverage. He argues that the negative impact of asset substitution and risk shifting outweighs increased debt capacity. However, the former aspects are unlikely to be relevant in our setting because neither risk shifting nor asset substitution is easily possible in the context of power plants. Thus, we are able to isolate the impact of production flexibility on leverage via debt capacity. Other studies analyze financing decisions and operational leverage in general (e.g., Mandelker and Rhee, 1984; Kahl et al., 2012) or employment flexibility

[1] Technologies for electricity generation are highly standardized and limited in number, which is underlined by the fact that the world market for the manufacturing of power plant equipment is dominated by only three companies (McGovern and Hicks, 2004). This allows us to assign a technology specific value for run-up time, ramp-up cost, and full-load hours.

(e.g., Hanka, 1998; Kuzmina, 2012).[2] However, none of these studies applies a direct measure for production flexibility.

Indirect measures, which are often based on balance sheet information, provide important insights, but they also face several problems. *First*, they often capture only realized flexibility. However, the existence of flexibility and not its realization may influence financing decisions of firms. *Second*, indirect measures are hard to interpret. In particular, it is often difficult to ensure that these proxies measure really the effect which should be analyzed. For example, accounting-based measures for flexibility might be influenced by factors like accounting rules or earnings management. *Third*, endogeneity may be a problem if indirect measures are applied. However, identification strategies are of huge importance as financial leverage and production flexibility might be jointly determined by firms.

To investigate the relationship between leverage and production flexibility, we start by performing pooled OLS, firm-fixed effects, and system-GMM regressions. All these models point at a positive relationship. For identification, we first exploit the deregulation of electricity markets and the wave of privatizations in the 1990s as exogenous shocks. Financing was unlikely to influence production characteristics before deregulation and privatization because (i) public ownership allowed utilities to access capital via the state and/or (ii) the absence of competition allowed them to finance even large-scale projects without significant risks in a cost-plus pricing regime. In contrast, production characteristics have been mainly influenced by such other factors as political preferences (Peltzman and Winston, 2000). Consequently, the production characteristics of energy utilities before privatization and deregulation can be regarded as being independent of financing decisions. Using pre-deregulation and pre-privatization production flexibility as instruments confirms the prior results.

As a further identification strategy, we use natural gas and electricity prices in a specific region as instruments for production flexibility. As gas fired power plants are among the most flexible means of electricity generation, we expect lower gas prices to be correlated with higher production flexibility. In a similar vein, higher electricity prices make the construction of flexible gas power plants more attractive. Lastly, we use coal, gas, and oil reserves in U.S. states as instruments. For example, higher gas reserves are expected to lead to the construction of more flexible gas-fired

[2] Some other strands of the literature are also slightly related to our study. Benmelech (2009), for instance, focuses on debt maturity in his analysis of the 19^{th} century railroad industry. He also investigates determinants of leverage, but finds no evidence for an influence of asset salability. Campello and Giambona (2013) demonstrate that asset redeployability is an important determinant of leverage. Byoun et al. (2013) report evidence that operational characteristics of project financings are important determinants of leverage. Ortiz-Molina and Phillips (2013) show that lower asset liquidity reduces a firm's operating flexibility and increases cost of capital. In a similar vein, Chen et al. (2011) find that labor unions lead to higher cost of equity due to lower operational flexibility.

power plants. At the same time, natural resource reserves are plausibly exogenous as they are unlikely to influence firms' capital structures directly. Rather, they represent a given physical feature of a region. Both IV approaches confirm the positive relationship between production flexibility and leverage.

The direct measurement of production flexibility comes at the cost that only energy utilities are considered. As many other industries, these firms are regulated to some extent. However, the majority of this regulation nowadays focuses on factors that directly impact financing decisions. Nevertheless, we follow several strategies to alleviate concerns that the results are biased by peculiarities of energy utilities. First, firm-fixed effects regressions control for any time-invariant impact of regulation. Second, we restrict our analysis to firms located in regions with liquid wholesale markets for electricity. The introduction of wholesale markets for electricity is often regarded as the last step in the deregulation process. Third, we control for public ownership. All these robustness tests confirm our prior results.

Next, we analyze how access to financing impacts the relationship between production flexibility and leverage. In the model of Mauer and Triantis (1994), a positive impact of production flexibility on leverage increases with recapitalization costs. Exploiting variation in investor protection over countries provides empirical support for this prediction. We find that the impact of production flexibility on capital structure decisions is less pronounced in countries with better investor protection. Furthermore, we analyze if stock returns after the collapse of Lehman Brothers depend on firms' levels of production flexibility. If production flexibility is more important for firms when external financing is difficult, those with lower flexibility are expected to suffer more from a depletion of external financing opportunities. Indeed, we find that higher production flexibility led to higher (i.e., less negative) abnormal returns around the Lehman Brothers collapse. Finally, the question how product market uncertainty affects the relationship between production flexibility and capital structure is investigated. Mauer and Triantis predict also that the positive impact of production flexibility on leverage increases with the price volatility of the firm's product. To investigate this, we collect hourly electricity price data for 26 markets around the world. In line with our expectations, we find that the positive impact of production flexibility is more pronounced if electricity prices are volatile.

The remainder of this paper is structured as follows. Data and variables are presented in Section 2. The relationship between production flexibility and leverage is analyzed in Section 3. This section also includes descriptive statistics and robustness tests. Section 4 presents identification strategies. The impact of financial flexibility, i.e., low recapitalization cost, is analyzed in Sections 5.1. Section 6 concludes; it discusses the implications of the findings and provides avenues for future research.

2. Data and methodology

2.1. Sample construction

The sample covers energy utilities from all over the world. For its compilation, we start by combining lists of active and inactive utility companies from OneBanker and Datastream, both products of Thomson Reuters. We focus on stock market listed utilities because reliable data for unlisted firms is often not available. The sample is organized as unbalanced panel and covers the years 2002 to 2009 as this is the period for which we can obtain the necessary data on firms' production characteristics. Several steps are conducted to ensure the adequacy of this sample for our purposes.[3] Our final sample for which we have data on market leverage from Worldscope and on production characteristics covers 2,449 firm-year observations from 460 firms, located in 57 countries. Figure 1 shows the countries—and states for the U.S., Canada, and Australia—which are included in this sample.

— Figure 1 about here —

2.2. Production flexibility

First, we introduce the WEPP database and explain how the power plants are matched to our sample. After that, the calculation of the measures for production flexibility is explained.

The WEPP database

All information on firms' production characteristics are based on the WEPP database, which is published by Platts. This is the most comprehensive database on power plants. It contains power plants of all sizes and technologies around the globe. Practitioners such as analysts of energy utilities and management consultants regularly use this database for their analyzes. It contains information on single power plant units. These include, among others, their specific production technologies, capacities, geographic locations, start dates of commercial operation, and their owners/operators.[4]

[3] *First*, we eliminate all firms without a primary security classified as equity (5 firms). *Second*, all companies that were never active between 2002 and 2009 are excluded (138 firms). *Third*, and to ensure that our sample only covers companies that focus on the generation of electricity, we check the industry classification of all utilities. For this, we mainly rely on their SIC and ICB codes. In total, we eliminate 426 firms that do not fulfill our criteria of an energy utility. These removed firms are, among others, utilities specialized in water supply or gas transmission.

[4] A detailed description of the database is provided by Platts' "data base description and research methodology" (http://www.platts.com/IM.Platts.Content/downloads/udi/wepp/descmeth.pdf). Concerning the coverage of the database, Platts states that "[t]he WEPP Data Base covers electric power plants in every country in the world and includes operating, projected, deactivated, retired, and canceled facilities. Global coverage is comprehensive for medium- and large-sized power

We rely on this database because information on production assets reported by energy utilities on their websites or annual reports leads to several problems. *First*, relevant data are often not available because there are no disclosure requirements. *Second*—and closely related to first—there is no standardized disclosure of such data. Hence, firms may engage in selective reporting. One example for this can be that firms with nuclear power plants do not report details on production technologies due to the controversial public debate on this technology. *Third*, even if firms report details on their production assets, the level of detail differs substantially. Consequently, we decided to rely exclusively on the WEPP database in order to obtain detailed and unbiased data on firms' production assets.

The problem, however, with this database is that all data are unconsolidated and reported for single power plant units. Hence, it is necessary to match the single power plants to our sample firms. We conduct this by manually matching the WEPP database item COMPANY to the names of our sample companies.[5] It is important to note that we use the edition of the WEPP database which corresponds to the respective sample year. Hence, we deploy eight different editions of this database. Using only the most recent version would cause a bias because the most recent owner reported in the database might not necessarily have been the owner over the whole sample period. For example, the ownership of a power plant can change due to defaults and subsequent asset sales, mergers, or asset deals.

Table 1 provides an overview on the data included in the WEPP database. In total, 114,664 power plants are included in the database in 2009. They account for an overall capacity of 4,732 GW. We only consider those plants that are in operation and hence exclude those under construction/planning or already mothballed in the respective year. This figure is consistent with the International Energy Agency (2011), which reports an installed capacity of 4,957 GW for 2009. We are able to match more than 50% of the installed capacity, i.e., about 2,500 GW, and approximately 30% of all power plants to energy utilities included in our sample. We maintain that this outcome does not seem implausible. The reason for this is that

plants of all types. Coverage for wind turbines, diesel and gas engines, photovoltaic (PV) solar systems, fuel cells, and mini- and micro-hydroelectric units is considered representative, but is not exhaustive in many countries. Nonetheless, about a quarter of the data base consists of units of less than 1 MW capacity. Generating units of less than 1 kW are not included" (p. 5). Thus, we consider the database to be representative for our analysis. With regard to the owner/operator of the power plants, Platts states that "[a]s a general matter, the listed COMPANY is both the operator and sole or majority owner" (p. 10). Although there might be exceptions, we argue that these are rare and unlikely to bias our results.

[5]Since the WEPP database item COMPANY does not necessarily equal a company name in our sample, but might be a subsidiary of such a company, we also use a subsidiaries list for our sample firms in the matching process. If a subsidiary is owned by more than one company in the sample, we assume that all owners hold equal parts of this subsidiary.

our sample only covers listed companies. Hence, all power plants held by privately-owned firms cannot be matched. Consequently, it cannot be expected that all power plants are matched to sample firms.

— Table 1 about here —

Production flexibility variables

Based on the information about single power plants, we construct three measures of production flexibility: run-up time, ramp-up cost, and full-load hours. We do not focus on one single measure because analyzing all three measures provides a more comprehensive picture on the interplay between production flexibility and leverage.

For the *first* measure, we make use of differences in the technology-specific RUN-UP TIME. Higher run-up times are expected to decrease the firm's production flexibility. The values used for the calculation as well as their sources are shown in Appendix B. We define the average run-up time of company i as follows:

$$\text{Run-up time}_i = \frac{\sum_{k=1}^{M} \text{Capacity}_k \cdot \text{Run-up time}_k}{\sum_{k=1}^{M} \text{Capacity}_k} \tag{1}$$

where k denotes a production technology and M the number of different technologies of an energy utility.

As a *second* measure, we use RAMP-UP COSTS. These are the cost for a hot start of a power plant. Again, values and sources for the different technologies are shown in Appendix B. More expensive shut-downs and start-ups are expected to decrease production flexibility. Thus, higher values of ramp-up cost go along with less production flexibility. It should be noted that this definition is very similar to the one used by Mauer and Triantis, who argue that "lower costs of shutting down and reopening a production facility" (Mauer and Triantis, 1994, p. 1253) increases production flexibility. We define average ramp-up costs of company i as follows:

$$\text{Ramp-up costs}_i = \frac{\sum_{k=1}^{M} \text{Capacity}_k \cdot \text{Ramp-up costs}_k}{\sum_{k=1}^{M} \text{Capacity}_k} \tag{2}$$

The *third* measure is FULL-LOAD HOURS. For its construction, we focus on the merit order of Germany. The first reason for this is that electricity production in Germany is based on a wide variety of technologies. Second, data is available from the Federal Statistical Office of Germany. Thus, the applied values refer to full-load hours of German power plants in 2007. Although this might not be perfectly representative for other countries, we argue that these values are a reliable approximation.[6] Full-load hours are defined as the hypothetical number of hours within one

[6] Alternatively, it would be necessary to perform a country-specific modeling of the merit order.

year that would be necessary to generate the actual electricity output, assuming that the plant is operated at its full-load (i.e., with its maximum capacity). Instead of using the yearly hours, we divided full-load hours by 8760 yearly hours to obtain the fraction of full-load hours. Thus, a value of 0.5 means that the plant-type runs on full-load in 50% of all hours. Technology-specific values are shown in Appendix B. Because a lower number of full-load hours goes along with more frequent shut-downs and start-ups, more full-load hours indicate lower production flexibility.

$$\textsc{Full-load hours}_i = \frac{\sum_{k=1}^{M} \text{Capacity}_k \cdot \text{Full-load hours}_k}{\sum_{k=1}^{M} \text{Capacity}_k} \quad (3)$$

Detailed definitions of all variables can be found in Appendix A. In Appendix C, we illustrate the calculation of the production variables with an example.

2.3. Financial variables

The main LEVERAGE measure in this paper is defined as total debt divided by the sum of total debt and the book value of a firm's equity. Alternative leverage definitions are applied in a robustness test. The variables for which we control in all regressions are size, profitability, tangibility, and growth opportunities. Their inclusion is motivated by Frank and Goyal (2009). SIZE is parametrized by the natural logarithm of the firm's total assets in U.S. dollar. PROFITABILITY is defined as EBITDA divided by total assets. TANGIBILITY is plant, property and equipment divided by total assets. To account for differences in growth opportunities, we control for the MARKET-TO-BOOK ratio. Besides these variables, we also include DIVIDEND PAYOUT. This dummy variable equals one if the firm pays a dividend in the respective year and zero otherwise. Detailed definitions can be found in Appendix A. Furthermore, we include country and year dummies to account for country- and year-specific effects, e.g., taxes or specific regulations. Firm-years with data errors are not considered: *First*, we demand that the leverage is between zero and one. *Second*, we require that PROFITABILITY is higher than minus one and, *third*, that MARKET-TO-BOOK is higher than zero. To restrict the impact of outliers, all financial variables are winsorized at the 1% and 99% levels.

2.4. Methodology

The main estimation methodologies are pooled-OLS and firm-fixed effects regressions. The pooled-OLS model is defined as follows:

Such modeling for an international sample requires commodity and electricity market prices, plant specific marginal costs like fuel transportation costs or costs for CO_2 emission allowances, and several country-specific parameters such as time-dependent demand curves, market design parameters, and cross-border transmission capacities. As necessary data are often not available, we cannot perform such country-specific modeling of merit orders.

$$Leverage_{i,t} = \alpha + \varphi \cdot R^{\text{production}}_{i,t-1} + \eta \cdot C^{\text{financial}}_{i,t-1} + \beta \cdot d^{\text{country}}_{i} + \gamma \cdot d^{\text{year}}_{t} + \epsilon_{i,t} \quad (4)$$

with φ and η being vectors of coefficients and $R^{\text{production}}$ and $C^{\text{financial}}$ being the vectors of the *production-specific* and *financial* regressors. Furthermore, the model includes a constant term α. The dummy variables d^{country}_{i} and d^{year}_{t} with their coefficient vectors β and γ control for country- and year-fixed effects. Variables denoted in Greek letters are estimated in the regression. While i represents the company index, t is the time index. For causality reasons, all regressors must be in the information set of the dependent variable. Therefore, they are lagged by one period. Alternatively, we apply firm-fixed effects regression which includes a firm-specific fixed effect α_i:

$$Leverage_{i,t} = \alpha_i + \varphi \cdot R^{\text{production}}_{i,t-1} + \eta \cdot C^{\text{financial}}_{i,t-1} + \gamma \cdot d^{\text{year}}_{t} + \epsilon_{i,t} \quad (5)$$

The strong advantage of this model is that it controls for any time-invariant omitted variables. Consequently, the firm-fixed effects makes country dummies redundant. Since our data has a panel structure, we apply cluster-robust Huber/White standard errors (White, 1980) which are adjusted for clustering within firms (Petersen, 2009). If country-level variables, such as investor protection, are included in a regression, standard errors are adjusted for clustering within firms and countries (Cameron et al., 2011; Thompson, 2011).

3. Production flexibility and leverage

3.1. Descriptive statistics

Table 2 depicts descriptive statistics of all relevant variables, averaged from 2002 until 2009. For the production related variables, it can be seen that the average run-up time is 2.77 hours, with variation between 0.08 hours for the 25% percentile and 3 hours for the 75% percentile. Average ramp-up cost are 28.05 € per MW. On average, power plants are operated at full load in 34% of all hours. Concerning the asset age, we find that the average age is about 20 years. Furthermore, about 80% of all energy utilities own power plants in only one country.

For the financial variables, it can be seen that the average leverage is 43%. For an international sample covering the years 1991 to 2006, Öztekin and Flannery (2012) report an average book leverage of 24%.[7] The higher book leverage in our sample

[7]Please note that the book leverage definition of Öztekin and Flannery (2012) differs slightly from ours because they divided total debt by total assets, not by total equity plus total debt. Using their definition, we find that book value is about 30%.

may be explained by the fact that tangibility and—as a consequence—debt capacity is on average higher in the energy utilities industry. While we find a mean value of 56% for tangibility, Öztekin and Flannery report a value of only 37%. Another interesting finding is that nearly two-thirds of our sample firms pay dividends. This is higher as for multi-industry samples and reflects that energy utilities are often mature firms with limited growth opportunities.

— Table 2 about here —

3.2. Main results

Next, we analyze the relationship between production characteristics and capital structure. Results are reported in Table 3. In model I, production flexibility is measured with run-up time. Both pooled-OLS and firm-fixed effects regression indicate a negative relationship between run-up time and leverage with a significance level of 1%. Because higher values for run-up time go along with lower production flexibility, leverage is higher in firms with higher flexibility. The economic significance of this finding is large. For example, based on firm-fixed effects estimates for run-up time, a hypothetical firm with only gas-fired power plants would choose a leverage that is about 5% (in absolute terms) higher than an otherwise identical utility with only lignite-fired power plants. As another example, there would be a nearly 10% difference between two hypothetical energy utilities, with one having only oil and and the other one only waste-fired power plants. A one standard deviation increase in run-up time leads to a about 4% decrease in leverage. The corresponding figures for tangibility and profitability are, for comparison, below 3%. Results for ramp-up cost (model II) and full-load hours (model III) are also of high statistical and economic significance and point in the same direction. Control variables are discussed in the Section 3.5. Overall, the outcome is in line with the view that higher production flexibility leads to higher leverage.

— Table 3 about here —

3.3. General robustness tests

Now we analyze the robustness of these findings. The results do not change substantially if we apply several alternative control variables, do not winsorize the financial variables, use contemporaneous instead of lagged independent variables, or exclude the dividend variable, which is not considered by Frank and Goyal (2009).

3.4. System-GMM approach

Next, we apply system-GMM estimation with lagged leverage as independent variable. This allows us to capture the dynamic nature of the firm's debt-equity choice (e.g., Flannery and Rangan, 2006). A simple OLS estimation would not be appropriate in this context because of the "dynamic panel bias" (Nickell, 1981). Hence, we apply a generalized method of moments (GMM) estimator that was developed for dynamic models of panel data. In particular, we use the *system-GMM* estimator proposed by Blundell and Bond (1998).[8] Results for the one-step (two-step) estimator are reported in Table 4, model I (II). As expected, lagged leverage has a strong positive impact across all specifications. The estimated adjustment speed is similar as in Öztekin and Flannery (2012) who analyze a worldwide, multi-industry sample. For the production flexibility measures, we find again that higher production flexibility leads to higher leverage.

— Table 4 about here —

3.5. Peculiarities of energy utilities

Unlike most other empirical finance studies, our sample only includes energy utilities. This is, however, in line with recent studies which also focus on energy utilities. Fabrizio et al. (2007), for instance, analyze if markets can reduce costs. Becher et al. (2012) investigate corporate mergers and Perez-Gonzalez and Yun (2013) disentangle the value contribution of risk management with derivatives. Nevertheless, the question if capital structure decisions of utilities are systematically different from other industries due to their regulatory environment may arise.

The energy utility industry is *largely deregulated* in most countries nowadays (Dewenter and Malatesta, 1997). Ovtchinnikov (2010) assumes, for instance, that energy utilities in the U.S. were regulated until 1987. However, some aspects which are not directly related to financing decisions can still be influenced by regulation. For example, grid access fees are often determined by federal entities. A more comprehensive discussion of regulation is provided in Section 4.1. However, a certain degree of regulation exists in most industries. Among others, in the U.S. the drug admission process for the pharmaceutical industry is regulated by the FDA, chemical industry has to fulfill the Toxic Substances Control Act, and all firm have to comply with rules set by the FTC.

Nevertheless, we investigate if the *factors determining capital structures* are systematically different for energy utilities. Thus, we first discuss the financial control variables shown in Table 3. Size and tangibility have a positive impact on leverage, while the opposite is true for the dividend dummy. The statistical significance

[8]Following González and González (2008), two to four-period lags of the right-hand side variables are used as instruments. For the production flexibility variables, we use the values as of 1995 as instruments (cf. Section 4.1). We apply both the one-step and the asymptotically more efficient two-step system-GMM version. As standard errors might be downward biased in the latter case, they are adjusted with the finite sample correction proposed by Windmeijer (2005).

of these results is strong. For profitability, we find negative signs in both models and statistical significance in the firm-fixed effects model. These findings are in line with prior empirical studies covering multi-industry samples. For market-to-book, we find a positive impact.[9] Overall, we argue that capital structure in the utility industry is determined by similar factors as in other (non-financial) industries.

Furthermore, it should be noted that we apply firm-fixed effects regression and pooled-OLS regression with country- and year fixed effects to control for unobserved heterogeneity (Gormley and Matsa, 2013). Thus, we control for country-specific regulations in all models. Not reported results for county-year dummies also control for country-year specific factors. Even more, the firm-fixed effects regression controls for all time-invariant factors. As all models indicate a positive impact of production flexibility on leverage, we argue that energy utility peculiarities, e.g., regulation of the grid, are unlikely to bias our results.

Liquid wholesale market

As next test, we construct a sub-sample of firms operating in deregulated markets. As it is unfeasible to identify a particular year in which an electricity market in a particular country was deregulated because this is a step-wise process, we focus on the introduction of a competitive wholesale markets for electricity. This is commonly regarded as the last step in the deregulation process. Thus, we only include firm-years if a competitive wholesale market for electricity exists. As no nation-wide electricity markets exist in the U.S., Canada, and Australia, we focus on single states in these countries. We use press and web search to obtain the necessary information. If we find no convincing evidence for the existence of a competitive wholesale market, we conservatively assume that there is no such market. Figure 2 shows if there was a competitive wholesale market in at least one year during our sample period for all sample countries/states.

— Figure 2 about here —

Results for the relationship between leverage and production flexibility in countries and years with competitive wholesale markets can be found in Table 5, model I. Alternatively, we only include firms located in countries in which a competitive

[9] At first glance, this is surprising as prior literature mainly supports a negative relationship. However, as also indicated by Frank and Goyal (2009), this effect is not reliable for book leverage, but only for market leverage. For the latter, we also find a negative impact in OLS models. Furthermore, we argue that the positive effect for book leverage does not indicate a different behavior of energy utilities. Instead, it may simply reflect that growth opportunities of energy utilities are mostly limited. In this context, Chen and Zhao (2006) show that the impact of market-to-book on book leverage is positive for most firms and that a negative effect is driven by a small number of firms with very high market-to-book ratios.

wholesale market exists since 2002. The firm-fixed effects regression confirm our prior findings: higher production flexibility leads to higher financial leverage. Thus, we argue that regulation of electricity markets is unlikely to bias our results.

— Table 5 about here —

Public ownership

We also analyze the impact of public ownership. Due to historical reasons, public ownership may still be common for energy utilities. Information on firms' owners comes from the Thomson Reuters Global Ownership database. This allows us to construct a dummy variable PUBLIC OWNERSHIP which equals one if the state or any federal entity is among the three largest shareholders in a specific year and zero otherwise. The state remains an important shareholder in about 10% of all firm-years. In Table Appendix 1, we control for public ownership. The impact of public ownership is insignificant and the effect of production flexibility remains unchanged. Thus, we conclude that public ownership does not bias the prior results.

3.6. Production characteristics

In this robustness test, we analyze if the results are biased by any technology-specific effects. For example, it could be argued that an influence of renewable technologies on leverage is not related to production flexibility, but other factors such as government aid. Thus, we consecutively exclude firms owning at least one plant with the following technologies: coal (hard coal and lignite), gas, nuclear, oil, and renewables (hydro, wind, and solar). Results for run-up time based on firm-fixed effects can be found in Table 6. The magnitude and statistical significance of the coefficient for run-up time remains rather unchanged if the different technologies are excluded. Results for ramp-up cost and full load hours are reported in Table Appendix 2. We conclude that the impact of production flexibility on leverage represents a general effect which does not depend on any specific technology.

— Table 6 about here —

Furthermore, we additionally control for asset age and regional diversification as other production characteristics. ASSET AGE controls for differences in the investment cycles of utilities. It is defined as the capacity-weighted average age of the power plant portfolio of a company. REGIONAL DIVERSIFICATION measures production diversification across countries. It is constructed as a dummy variable that equals one if a energy utility owns power plants in more than one country and zero otherwise. Results are reported in Table Appendix 3. Neither asset age nor regional diversification have a significant effect in the firm-fixed effects model. As before, higher production flexibility leads to higher leverage.

3.7. Leverage definition

Lastly, we challenge the results' robustness by applying alternative leverage definitions. These are MARKET LEVERAGE, LONG-TERM BOOK LEVERAGE, and NET BOOK LEVERAGE. For the calculation of market leverage, the book value of equity is replaced by market value. For long-term leverage, only long-term debt is considered for the calculation of long-term book leverage. Cash and short term investments are subtracted from total debt for the construction of net leverage. The detailed construction of all leverage variables can be found in Appendix A. Results for this test are shown in Table Appendix 4. Overall, we conclude that our prior result of a positive relationship between production flexibility and leverage does not depend on any specific leverage definition.

4. Identification strategies

Results so far indicate that production flexibility has a positive impact on leverage. However, endogeneity could bias this finding because leverage and production flexibility might be jointly determined by firms. For example, firms with better access to finance may have lower production flexibility because they are more likely to build power plants with high capital expenditures and low flexibility, like nuclear power plants. If better access to finance leads to more equity financing, causality would run from financing decisions to production flexibility.[10] As identification strategies, we (i) exploit the deregulation and privatization of energy utilities, (ii) apply gas and electricity prices, and (iii) coal, gas, and oil reserves as plausibly exogenous instruments for production flexibility.

4.1. Deregulation and privatization

We exploit the privatization of energy utilities and the deregulation of electricity markets over the last decades as exogenous shocks. There are two reasons why these events can be used for identification. The first reason is that energy utilities were mostly publicly owned before privatization (Dewenter and Malatesta, 1997). These publicly owned utilities profited from loan guarantees and access to capital via the state.[11] Thus, not financing constraints, but factors like political preferences determined the production characteristics of publicly owned energy utilities.[12]

[10] Benmelech (2009) uses a similar argument in the context of track gauge and financing decisions.

[11] For example, Dewenter and Malatesta (2001) state that energy utilities had "implicit or explicit loan guarantees enabling them to borrow at favorable rates, or they may borrow from the government itself at favorable rates" (p. 312).

[12] However, two important exceptions are the U.S. and Japan. Investor owned energy utilities accounted for the majority of electricity production in the United States since the 19^{th} century (Masten, 2010). During the 1990s, nearly all U.S. states restructured the utility sector to increase competition (Fabrizio et al., 2007). Moreover, Japan privatized energy utilities already in 1951.

The second reason is that many countries deregulated the energy industry in the 1990s. Before that, even the construction of very expensive power plants, e.g., nuclear plants, was virtually riskless because markets were not competitive. Hence, cost could be recovered from costumers by cost-plus pricing based on production costs. In such a business environment, financing constraints were unlikely because future cash-flows were highly predictable. Hence, the production technology decision in this industry was likely not driven by financing constraints, but by such other factors as political preferences. In this context, Peltzman and Winston (2000), p. 121, state that "[o]ne of the potential benefits of creating competitive decentralized markets for wholesale power is to bring these politicized resource planning process to an end [...]."

Both reasons indicate that financing constraints had no impact on the production characteristics of state-owned and/or highly regulated energy utilities. Hence, using before-privatization and deregulation production characteristics to explain the after-privatization capital structure rules out the possibility of reverse causality. In our empirical design, we perform an IV regression with values of the flexibility measures as of 1995 as instruments.[13] As expected, the values as of 1995 have a high statistical and economic significance in explaining contemporaneous flexibility values (cf. Table Appendix 5). Second-stage results are reported in Table 7. In model I, all utilities are included. Because only deregulation, not privatization took place in the U.S. and Japan in the 1990s, we also report results without utilities from these two countries in model II. As before, higher production flexibility leads to higher financial leverage.

— Table 7 about here —

Alternatively, we consider only utilities located in the E.U. (and Norway) that started electricity exchanges—as the last step of deregulation—between 1995 and 2003. We focus on E.U. countries because they underwent a rather homogeneous deregulation process. In 1995, electricity markets in E.U. countries were largely regulated. In 1996, E.U. directive 96/92/EC demanding that all member states deregulate their electricity markets was issued. In the early 2000s, the majority of E.U. markets were deregulated. However, the speed of deregulation was different

[13] This year is chosen because power plants which were in operation in 1995 have been largely planned and constructed before the start of the deregulation and privatizations. Production characteristics for the year 1995 are derived from the 2002 edition of the WEPP database, which is the earliest edition available. All units with a start of commercial operation later than 1995 are excluded. Nevertheless, as argued in Section 2.2, using ownership information as of 2002 for 1995 can cause a bias. Besides that, it is difficult to define the exact start date of the privatization and deregulation process, especially for an international sample. Although both events often took place at the same time, there were deviations in some countries. Furthermore, this is often a stepwise process, not a one-time event. Nevertheless, we argue that a potential bias should be small.

among member countries. Thus, we identify those countries that started an electricity exchange before 2003 and include only observations from utilities located in these countries.[14] Furthermore, we consider only firm-years after 2004 to ensure that the exchanges were already in place for some time. Results for this sub-sample can be found in model III. Again, we find strong evidence that higher production flexibility leads to higher leverage.

4.2. Gas and electricity prices as instruments

However, one might still argue that endogeneity biases our results because we cannot "prove" that production flexibility before L&D was completely independent of financing decisions. Although we do not believe that this is likely, there might be reasons why, for example, governments aligned highly flexible production assets to energy utilities with high or low leverage ratios.

As an alternative test, we exploit variations of natural gas and electricity prices across regions as instruments for production flexibility. Gas fired power plants are among the most flexible means for electricity production. The major cost factor for these plants in the price of natural gas. Thus, this price determines if the operation of such plants is profitable. Consequently, we expect that a lower gas price leads to the construction of more power plants and thus higher flexibility of energy utilities. Similarly, also higher electricity prices make the construction of gas-fired power plants more profitable. Due to their high variable cost, they are only switched on if market price for electricity is above a certain threshold. Consequently, higher electricity prices are expected to lead to more flexible power plants and thus to higher production flexibility.

For this test, we restrict the sample to the U.S., Canada, and Australia. In these countries, electricity and—for the U.S.—gas prices differ across regions. This allows us to include country-fixed effects while still exploiting price differences across regions. Consequently, we use the average electricity and gas price in a particular region as instruments.[15] Results are reported in Table 8. We find that higher gas prices lead to less flexibility, as expected. The opposite is true for electricity prices. Based on the Kleibergen-Paap rk Wald F statistic, we cannot completely rule out

[14] These countries are Austria (started exchange in 2002), Denmark (2000), Finland (1998), France (2001), Germany (2002), Netherlands (1999), Norway (1995), Poland (2000), Spain (1998), Sweden (1996), and the U.K. (2001).

[15] The average price of gas and electricity in a region is calculated over the whole sample period. Gas prices are collected from the Energy Information Association (EIA) for U.S. states. We use the natural gas price for electricity generation in U.S. dollar per thousand cubic feet. Gas prices for at least on year can be obtained for all U.S. states except Hawaii. For Canada and Australia, we assume a fictional gas price as this does not affect the outcome due to the country-fixed effects. Electricity price is the daily average price of equally weighted hour contracts, measured in U.S. dollar per megawatt hour. Details on coverage and data collection are provided in Section 5.2.

the possibility of a weak instruments problem for ramp-up cost . For run-up time and full-load hours, there is no indication of such problem. The second-stage results confirm the prior findings. Overall, this test provides further evidence for a causal relationship between production flexibility and financing decisions.

— Table 8 about here —

4.3. Coal, gas, and oil reserves as instruments

The necessary assumption for using average gas and electricity prices as instruments is that they do not directly affect firms' debt-equity choices. We argue that such direct impact is unlikely and that gas and electricity prices are plausibly exogenous. However, Roberts and Whited (2012) argue that "[g]ood instruments come from biological or physical events or features." (p. 27). This is, of course, not the case for gas and electricity prices. As alternative instruments, we apply physical features of U.S. states: their natural reserves of coal, gas, and oil. Data for the reserves are obtained from the U.S. Energy Information Administration.[16]

We argue that natural resources of a state influence average production flexibility of energy utilities located there. In particular, higher gas reserves are expected to increase the probability that gas-fired power plants are built, thus increasing production flexibility. The opposite is true for coal reserves, which should lead to more less flexible coal-fired power plants. For oil reserves, we expect no direct impact on energy utilities' production facilities because oil-fired power plants are uncommon in the U.S. By contrast, oil reserves are expected to increase energy demand, e.g., due to energy intensive refineries. Higher energy demand leads to more large-scale base-load power plants, which are less flexible. At the same time, reserves of natural resources are very unlikely to influence firms' financing decisions via other channels than production flexibility. Using data for reserves as of 1995 further reduces concerns about a direct impact.

Results can be found in Table 9. First-stage regressions indicate that gas reserves increase production flexibility. Oil reserves have a contrary effect. For coal, we also find a negative, although mostly not significant, impact on production flexibility. All these findings are in line with our expectations. The Kleibergen-Paap rK Wald F statistic (Kleibergen and Paap, 2006) indicates that there is no weak instruments

[16]We use data on reserves as of 1995 to further reduce the possibility of a direct influence of the reserves on firms' financing decisions. In particular, the data comes from the U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves 1996 Annual Report and the Coal Industry Annual Report 1995. For oil and gas reserves, both on and offshore reserves of a state are considered. We focus on dry natural gas reserves. For coal, we exclude states for which data on reserves in withheld. If a state is only listed as "miscellaneous", we assume that there are no natural reserves.

problems for run-up time and full-load hours. For ramp-up cost, however, the instruments perform worse. Thus, these results should be interpreted with caution. Indeed, we find no significant impact of ramp-up time on leverage in the second-stage regression. The outcome for run-up time and full-load hours, however, confirms our prior findings. Overall, this test provides further evidence for a positive and causal impact of production flexibility on leverage.

— Table 9 about here —

5. Financial flexibility and price volatility

5.1. Financial flexibility

In their paper, Mauer and Triantis (1994) argue that "production flexibility and financial flexibility are, at least to some degree, substitutes [...]." (p. 1263). In particular, the positive impact of production flexibility on the value of the interest rate tax shield is less pronounced in their model if financial flexibility is high, i.e., recapitalization cost are low. Intuitively, firms that can manage their capital structure at lower cost benefit less from the flexibility provided by higher levels of production flexibility. Consequently, we expect that the positive impact of production flexibility on leverage is less pronounced if financial flexibility is high. However, firm-specific measures for financial flexibility are likely endogenous because they are jointly determined with production flexibility and leverage. Thus, we follow two alternative strategies to empirically investigate this prediction: variations of investor protection across countries and the default of Lehman Brothers.

Variation of investor protection

The global sample allows us to analyze how country-level investor protection affects the impact of production flexibility on leverage. If production flexibility and financial flexibility are substitutes, we expect that the positive impact of production flexibility on leverage is less pronounced in countries with higher financial flexibility, i.e., lower recapitalization cost. To approximate the magnitude of recapitalization cost, we apply different measures. Thereby, we assume that better investor protection enhances firms' access to external finance (e.g., La Porta et al., 1997). Following McLean et al. (2012), we use seven indices "that the existing literature had shown to be most important for access to finance" (p. 346).[17] Because we focus on the impact of country-level variables on the interplay between production flexibility and

[17] These are COMMON, ANTI-SELF, LIABILITY, DISCLOSURE, PROTECT, ACCESS, and NON-ZERO. Data sources can be found in Appendix A. More details about their construction and interpretation are provided by the papers in which they are developed or in Appendix B of McLean et al. (2012).

leverage, other country-specific factors not related to access to equity can bias the results. To reduce potential concerns, we restrict the sample to firms located in countries in which a competitive wholesale market for electricity exists since 2002. In these 17 countries markets are highly deregulated, reducing concerns that country factors like regulation affect the outcome.

Results for run-up time based on firm-fixed effects regressions are presented in Table 10.[18] In each column, we include run-up time and its interaction with one of the seven country-specific variables. To ease interpretation, we center all investor protection variables except for the dummy COMMON. As can be seen, run-up time has, on average, a negative influence on leverage. However, this negative effect is reduced by better access to to finance because all interaction terms are positive and significant. For example, the effect in non-common law countries is about twice as high as in common law countries. Overall, this test shows that the positive relationship between production flexibility and leverage is less pronounced in countries with better access to finance.

— Table 10 about here —

Default of Lehman Brothers

Next, we exploit variation of recapitalization cost over time. The collapse of Lehman Brothers on September 15^{th}, 2008 represents an exogenous shock which suddenly depleted firms' external financing opportunities. This date is often regarded as the starting point of the 2008/2009 financial crisis and the credit crunch. In this test, we analyze stock market returns of energy utilities around this date. The level of production flexibility is not expected affect capital markets returns in general because it is already incorporated in the market prices. It may, however, have an effect on the performance in the case of such unexpected shocks. Based on the predictions of Mauer and Triantis (1994), we expect that firms with lower production flexibility suffer more if external financing opportunities deplete (and recapitalization costs increase), as after the collapse of Lehman Brothers.

For the analysis, we follow a two step approach. First, we calculate the abnormal event return for each company. Normal returns are predicted with a market model (MacKinlay, 1997).[19] The cumulative abnormal return (CAR) is calculated over an

[18] For ramp-up cost, we also find positive and mostly statistically significant interaction terms. For full-load hours, all interaction terms are also positive, but not statistically significant. This may be related to the fact that we apply the same values for technology-specific full-load hours for each country (i.e., we assume the same merit order for each country as simplification, cf. Section 2.2).

[19] We apply an estimation window starting 250 trading days and ending 30 days before the event window. As this analysis is performed from the perspective of U.S. investors, we use the return of the MSCI World index as market return. Furthermore, we rely on the firms' return indices in U.S. dollar. All stock market data is retrieved from Datastream.

event window which starts three days before and ends three days after the event ([-3,3]). Alternatively, we also apply a [-1,2] event window. In a second step, we explain the CAR by firm-specific factors. These are either leverage, size, and freefloat or the same control variables as in the main regressions plus leverage. Furthermore, we include country dummies and the a measure of production flexibility. Values as of the end of 2007 are applied for all explanatory variables to ensure that they are exogenous and not influenced by the event.

Results are reported in Table 11. We find evidence that firms with lower production flexibility had lower returns around the collapse of Lehman Brothers in all models. This holds true for all flexibility measures and both sets of control variables. The results for the [-1,2] event window, which can be found in Table Appendix 6, lead to the same conclusion: firms with high levels of production flexibility suffered less from the breakdown of external financing opportunities (and thus higher recapitalization cost), as predicted by Mauer and Triantis (1994).

— Table 11 about here —

5.2. Electricity price volatility

Mauer and Triantis (1994) argue that the impact of production flexibility on leverage increases with the volatility of the price of the product that is sold by the firm. Our dataset allows us to test this prediction empirically as energy utilities sell mainly one product, i.e., electricity. Because there is no comprehensive database available, we manually collect data on electricity prices around the world to exploit cross-country and time variation. We focus on hourly spot prices which provide a more comprehensive picture of the market than daily prices. The data is obtained from websites of electricity exchanges, directly from the exchanges, or from Thomson Reuters. Overall, hourly electricity spot price data is available for Australia (AMEO New South Wales, AMEO Queensland, AMEO South Australia, AMEO Victoria), Austria, Belgium, Canada (AESO, ISO NE, MISO, OIESO), Denmark, Estonia, Finland, France, Germany, Italy, Netherlands, Norway, Portugal, Poland, Russia, Singapore, Korea, Spain, Sweden, Switzerland, U.K, and U.S. (ERCOT, ISO NE, MISO, NYISO, OIESO, PJM). Firms and markets are matched based on the location of the firms' headquarters. We then calculate the volatility of the electricity price separately for each firm over its fiscal years (VOLATILITY).

Results for the interaction of the electricity price volatility over the firm's fiscal year with its level of production flexibility are reported in Table 12. As predicted by Mauer and Triantis, the impact of production flexibility on firms' capital structures increases with the volatility of the output price. This holds true for all three measures of production flexibility. Besides the high statistical significance, the effect also has a huge economic impact. For example, the effect of run-up time on leverage increases by about one-sixth if electricity price volatility goes up 10%.

— Table 12 about here —

6. Conclusion

In this paper, we examine the relationship between production flexibility and capital structure based on a global sample of listed energy utilities. Detailed information on their power plants, which are manually matched from the WEPP database, enables us to calculate three direct measures for production flexibility.

In line with theoretical predictions of Mauer and Triantis (1994), we find that firms with higher production flexibility rely more heavily on debt financing. This outcome is robust to several concerns. Most importantly, we provide evidence that utility-specific factors do not bias the findings. We follow several identification strategies. First, we exploit that production flexibility was unlikely to influence financing before deregulation and privatizations of energy utilities. Second, we use variations of electricity and gas prices across regions as instruments. Lastly, an instrumental variable approach based on coal, gas, and oil reserves of U.S. states, which are plausible exogenous, is applied.

Two further empirical tests provide evidence for a substitution effect between production flexibility and financial flexibility. First, the influence of flexibility on leverage is more pronounced in countries with worse access to finance, i.e., high recapitalization cost. Second, firms with higher production flexibility suffered less from the breakdown of external financing opportunities after the collapse of Lehman Brothers. Lastly, we find that the influence of production flexibility on leverage increases with electricity price volatility.

These findings contribute to a better understanding of the interaction between operational risk and financing decision. Most importantly, firms consider their production flexibility in capital structure decisions. This may, for example, help to shed light on firms' debt conservatism (Graham and Harvey, 2001). Furthermore, real flexibility is more important for firms if external financing is difficult and if product prices are volatile. Thus, production flexibility is a hitherto largely unstudied channel how firms' external environments impact their financing decisions. An important limitation is that we focus on production flexibility as one dimension of real flexibility. Thus, the impact of other forms of real flexibility, e.g., switching options, on capital structure decisions cannot be answered by this paper. Furthermore, the analysis focuses on one industry. Although we provide strong indication that our results are not driven by utility-specific factors, the development of direct flexibility measures for other industries is a promising area for future research.

Table 1: Descriptive statistics I/II: power plants

	Total in database		**Matched**			
Year	Capacity [MW]	plants [#]	Capacity [MW]		plants [#]	
2009	4,732,739	114,664	2,468,897	52%	31,760	28%
2008	4,523,533	108,960	2,360,368	52%	29,960	27%
2007	4,307,153	103,853	2,276,957	53%	28,597	28%
2006	4,099,429	98,824	2,143,608	52%	26,976	27%
2005	3,985,039	95,541	2,060,653	52%	26,101	27%
2004	3,887,686	93,307	2,008,247	52%	25,146	27%
2003	3,787,428	90,248	1,884,869	50%	23,957	27%
2002	3,662,830	87,220	1,826,514	50%	22,327	26%

This table depicts the total number and capacity of power plants in the edition of the Platts WEPP database in the respective year (columns 1 & 2). The last four columns show these figures only for those power plants which are matched to a firm that is included in our sample.

Table 2: Descriptive statistics II/II: sample

	Mean	**SD**	**25%**	**50%**	**75%**
Run-up time	2.77	4.48	0.08	1.54	3.00
Ramp-up costs	28.05	19.46	14.95	27.88	40.26
Full-load hours	0.34	0.12	0.21	0.37	0.41
Full-load hours [yearly]	2995	1085	1855	3205	3550
Asset age	19.89	13.56	7.99	19.75	29.08
Regional diversification	0.22	0.41	0.00	0.00	0.00
Volatility	0.24	0.16	0.14	0.20	0.27
Leverage	0.43	0.25	0.23	0.47	0.61
Size [US$ bn]	6.21	12.56	0.21	1.19	5.43
Profitability	0.10	0.10	0.07	0.11	0.14
Tangibility	0.56	0.26	0.40	0.62	0.77
Market-to-book	2.11	2.30	1.05	1.54	2.28
Dividend payout	0.64	0.48	0.00	1.00	1.00

This table shows descriptive statistics. A detailed description of all variables can be found in Appendix A.

Table 3: Capital structure and production flexibility

Model	Ia	Ib	IIa	IIb	IIIa	IIIb
Run-up time	**-0.0052*****	**-0.0083*****				
	(-3.55)	**(-3.34)**				
Ramp-up cost			**-0.0010****	**-0.0017****		
			(-2.32)	**(-2.19)**		
Full-load hours					**-0.27*****	**-0.17***
					(-4.04)	**(-1.94)**
Size	0.040***	0.10***	0.039***	0.099***	0.039***	0.10***
	(6.83)	(6.40)	(6.60)	(6.44)	(7.12)	(6.34)
Profitability	-0.18*	-0.26***	-0.17*	-0.26***	-0.18*	-0.26***
	(-1.89)	(-3.40)	(-1.80)	(-3.45)	(-1.90)	(-3.41)
Tangibility	0.19***	0.099*	0.19***	0.10*	0.21***	0.098*
	(3.98)	(1.82)	(3.98)	(1.84)	(4.31)	(1.79)
Market-to-book	0.018***	0.012***	0.018***	0.012***	0.019***	0.012***
	(3.56)	(2.99)	(3.55)	(2.99)	(3.55)	(3.03)
Dividend payout	-0.061***	-0.033**	-0.060***	-0.033**	-0.058***	-0.033**
	(-3.14)	(-2.08)	(-3.06)	(-2.12)	(-2.99)	(-2.08)
Observations	2,242	2,242	2,242	2,242	2,242	2,242
Adjusted R^2	0.39	0.16	0.38	0.15	0.39	0.15
Year-fixed effects	yes	yes	yes	yes	yes	yes
Country-fixed effects	yes	yes	yes	yes	yes	yes
Firm-fixed effects	no	yes	no	yes	no	yes

The dependent variable is LEVERAGE. Estimation models are pooled-OLS regression (model a) or firm-fixed effects regression (b). All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Appendix A.

Table 4: Robustness test: system-GMM estimation

Model	Ia	Ib	Ic	IIa	IIb	IIc
System-GMM		1-step			2-step	
Run-up time	**-0.0087*** **			**-0.0082***		
	(-2.60)			**(-1.96)**		
Ramp-up cost		**-0.0031*** **			**-0.0026** **	
		(-3.13)			**(-2.29)**	
Full-load hours			**-0.34*** **			**-0.26** **
			(-2.95)			**(-2.06)**
Leverage	0.73***	0.72***	0.72***	0.75***	0.71***	0.74***
	(17.1)	(15.1)	(16.6)	(13.9)	(12.2)	(13.8)
Size	0.020***	0.031***	0.019***	0.016**	0.027**	0.016*
	(2.91)	(3.45)	(2.69)	(1.99)	(2.39)	(1.93)
Profitability	-0.41***	-0.42***	-0.42***	-0.39***	-0.41***	-0.40***
	(-2.62)	(-2.67)	(-2.59)	(-2.67)	(-2.78)	(-2.72)
Tangibility	0.074	0.067	0.11	0.038	0.050	0.065
	(1.18)	(0.99)	(1.61)	(0.55)	(0.64)	(0.93)
Market-to-book	0.0090**	0.0083*	0.0091**	0.0046	0.0046	0.0047
	(2.07)	(1.85)	(2.03)	(1.40)	(1.28)	(1.27)
Dividend payout	0.0022	0.0086	0.0081	0.019	0.020	0.023
	(0.11)	(0.40)	(0.38)	(0.83)	(0.81)	(1.04)
Observations	2,243	2,243	2,243	2,243	2,243	2,243
Hansen-J p-value	0.44	0.51	0.48	0.44	0.51	0.48
Year-fixed effects	yes	yes	yes	yes	yes	yes
Country-fixed effects	yes	yes	yes	yes	yes	yes

The dependent variable is LEVERAGE. All models are system-GMM estimations (Arellano and Bover, 1995; Blundell and Bond, 1998). Two- to four-period lags of the right-hand side variables are used as instruments. Values as of 1995 are used as instruments for production flexibility. Robust standard errors are applied in the one-step system-GMM version. As standard errors might be downward biased in the asymptotically more efficient two-step system-GMM version, they are corrected for the finite sample bias (Windmeijer, 2005). ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Appendix A.

Table 5: Robustness test: electricity wholesale markets

Model	Ia	Ib	Ic	IIa	IIb	IIc
Sample	Year with market			Market between 02 and 10		
Run-up time	**-0.011*** **			**-0.015*** **		
	(-3.94)			**(-3.98)**		
Ramp-up cost		**-0.0015***			**-0.0024***	
		(-1.80)			**(-1.93)**	
Full-load hours			**-0.17**			**-0.27**
			(-1.36)			**(-1.66)**
Size	0.059***	0.058***	0.059***	0.063**	0.061**	0.062**
	(3.00)	(2.88)	(2.94)	(2.58)	(2.45)	(2.47)
Profitability	-0.15*	-0.16*	-0.16*	-0.16	-0.17	-0.17
	(-1.76)	(-1.79)	(-1.81)	(-1.50)	(-1.53)	(-1.55)
Tangibility	0.066	0.069	0.071	0.017	0.021	0.022
	(0.82)	(0.85)	(0.87)	(0.17)	(0.21)	(0.22)
Market-to-book	0.010	0.011*	0.011*	0.012*	0.013*	0.013*
	(1.65)	(1.70)	(1.70)	(1.89)	(1.94)	(1.96)
Dividend payout	-0.0095	-0.010	-0.0086	-0.015	-0.017	-0.014
	(-0.48)	(-0.54)	(-0.44)	(-0.52)	(-0.59)	(-0.48)
Observations	1,283	1,283	1,283	734	734	734
Adjusted R^2	0.086	0.075	0.074	0.10	0.089	0.088
Year-fixed effects	yes	yes	yes	yes	yes	yes
Country-fixed effects	yes	yes	yes	yes	yes	yes
Firm-fixed effects	yes	yes	yes	yes	yes	yes

The dependent variable is LEVERAGE. Only firms located in countries for which it could be verified that a competitive wholesale market for electricity existed in the respective year are included in model I. In model II, we only include firms located in countries in which a competitive wholesale market for electricity exists since 2002. Figure 2 provides an overview on the existence of electricity markets around the world. All models are firm-fixed effects regression. All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Appendix A.

Table 6: Robustness test: excluding technologies

Model	I	II	III	IV	V
Exclusion	Coal	Gas	Nuclear	Oil	Hydro/Wind/Solar
Run-up time	**-0.0096*** **	**-0.0076** **	**-0.011*** **	**-0.0078*** **	**-0.011*** **
	(-2.93)	**(-2.15)**	**(-3.34)**	**(-2.79)**	**(-2.89)**
Size	0.074***	0.094***	0.083***	0.070***	0.087***
	(3.21)	(4.38)	(4.61)	(2.75)	(2.99)
Profitability	-0.22**	-0.24**	-0.31***	-0.16	-0.44**
	(-2.06)	(-2.50)	(-3.31)	(-1.43)	(-2.05)
Tangibility	0.14*	0.27***	0.14**	0.20**	0.071
	(1.68)	(2.89)	(2.32)	(2.22)	(0.80)
Market-to-book	0.0059	0.0079**	0.0058*	0.0037	0.0024
	(1.42)	(2.24)	(1.95)	(0.74)	(0.37)
Dividend payout	-0.043*	-0.055**	-0.038**	-0.068***	-0.049**
	(-1.80)	(-2.16)	(-2.27)	(-2.66)	(-2.22)
Observations	935	789	1,548	857	604
Adjusted R^2	0.094	0.14	0.13	0.12	0.18
Year-fixed effects	yes	yes	yes	yes	yes
Country-fixed effects	yes	yes	yes	yes	yes
Firm-fixed effects	yes	yes	yes	yes	yes

The dependent variable is LEVERAGE. Firms owning power plants with certain technologies are excluded. For example, only firms that do not own coal-fired power plants are included in model I. Estimation models are firm-fixed effects regressions. All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Appendix A.

Table 7: Causality: flexibility values before deregulation & privatization as instruments

Model	Ia	Ib	Ic	IIa	IIb	IIc	IIIa	IIIb	IIIc
Sample		Full			Excl. U.S. / Japan			Europe	
Run-up time$_{\text{instr.}}$	**-0.0065***** **(-3.85)**			**-0.0083***** **(-3.13)**			**-0.013**** **(-2.52)**		
Ramp-up cost$_{\text{instr.}}$		**-0.0013**** **(-2.07)**			**-0.0013** **(-1.35)**			**-0.0032*** **(-1.85)**	
Full-load hours$_{\text{instr.}}$			**-0.42***** **(-4.49)**			**-0.48***** **(-3.50)**			**-1.15***** **(-4.06)**
Size	0.041*** (5.17)	0.038*** (5.01)	0.041*** (5.45)	0.043*** (3.87)	0.040*** (3.76)	0.043*** (3.94)	0.038* (1.73)	0.039** (2.03)	0.060*** (3.01)
Profitability	-0.17 (-1.55)	-0.16 (-1.46)	-0.14 (-1.31)	-0.11 (-0.89)	-0.095 (-0.75)	-0.078 (-0.60)	-0.27* (-1.81)	-0.22* (-1.65)	-0.15 (-1.10)
Tangibility	0.13** (2.07)	0.14** (2.21)	0.14** (2.26)	0.18** (2.38)	0.19** (2.50)	0.19** (2.45)	0.17 (1.01)	0.21 (1.26)	0.16 (1.07)
Market-to-book	0.021*** (3.38)	0.021*** (3.35)	0.022*** (3.43)	0.019** (2.36)	0.019** (2.42)	0.021** (2.44)	-0.021 (-1.35)	-0.020 (-1.44)	-0.024 (-1.49)
Dividend payout	-0.060*** (-2.70)	-0.059*** (-2.66)	-0.055** (-2.45)	-0.061* (-1.85)	-0.058* (-1.77)	-0.054* (-1.68)	0.093 (1.00)	0.12 (1.45)	0.12 (1.45)
Observations	1,505	1,505	1,505	962	962	962	177	177	177
Year-fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country-fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes

This table depicts the outcome of a second-state IV regression. Values as of 1995 are used as instruments for the flexibility measures. First-stage results are shown in Table Appendix 5. The dependent variable is LEVERAGE. In model II, firms located in the U.S. and Japan are excluded. Only firms that are located in European countries which introduced electricity power exchanges between 1995 and 2003 are included in model III. Furthermore, model III includes only observations after 2004. Independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Appendix A.

Table 8: Causality: gas and electricity prices as instruments

Model	Ia	Ib	IIa	IIb	IIIa	IIIb
Average electricity price	-0.15***		-0.53***		-0.0045***	
	(-4.87)		(-3.76)		(-5.35)	
Average gas price	1.81**		3.07		0.049**	
	(2.88)		(1.25)		(2.68)	
Run-up time$_{\mathbf{instr.}}$		**-0.026***				
		(-1.71)				
Ramp-up cost$_{\mathbf{instr.}}$				**-0.0074****		
				(-1.98)		
Full-load hours$_{\mathbf{instr.}}$						**-0.88****
						(-2.51)
Size	1.28***	0.092***	4.83***	0.095***	0.018***	0.075***
	(4.10)	(3.60)	(4.42)	(4.27)	(3.82)	(7.30)
Profitability	2.46	-0.19	8.40	-0.21	-0.15	-0.39*
	(0.45)	(-0.74)	(0.51)	(-0.89)	(-0.86)	(-1.70)
Tangibility	-6.35	0.0059	-21.0**	0.033	-0.020	0.16
	(-1.74)	(0.038)	(-2.61)	(0.26)	(-0.23)	(1.33)
Market-to-book	0.29**	0.017***	1.06**	0.017***	0.0030	0.012*
	(2.45)	(4.45)	(2.26)	(3.31)	(1.16)	(1.87)
Dividend payout	-0.27	-0.070***	-0.21	-0.065***	-0.0036	-0.066**
	(-0.22)	(-3.28)	(-0.043)	(-2.69)	(-0.19)	(-1.99)
Observations	383	383	383	383	383	383
Year-fixed effects	yes	yes	yes	yes	yes	yes
Country-fixed effects	yes	yes	yes	yes	yes	yes
K-P rk Wald F statistic	12.19		7.22		14.86	
Hansen J p-value	0.86		0.57		0.95	

Models a (b) show the outcome of a first (second) stage IV regression. In models a (b), the flexibility measures (LEVERAGE) are the dependent variables. Variations in prices of electricity and gas across regions are applied as instruments. We use the average gas and electricity price in a region over the sample period as instruments. The sample is restricted to the U.S., Canada, and Australia because electricity and—in the U.S.—gas prices differ across states in these countries. Independent variables are lagged by one period in the second-stage regressions. K-P stands for Kleibergen-Paap (see Kleibergen and Paap, 2006). T-statistics based on Huber/White robust standard errors clustered by firms and regions (i.e., electricity markets) are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Appendix A.

Table 9: Causality: coal, gas, and oil reserves as instruments

Model	Ia	Ib	IIa	IIb	IIIa	IIIb
Coal reserves	1.60		6.15		0.057**	
	(0.91)		(0.91)		(2.49)	
Gas reserves	-0.25***		-0.44*		-0.0063***	
	(-4.49)		(-2.02)		(-7.73)	
Oil reserves	1.15***		1.19*		0.023***	
	(6.30)		(1.80)		(6.38)	
Run-up time$_{\mathbf{instr.}}$		**-0.024*** **				
		(-3.20)				
Ramp-up cost$_{\mathbf{instr.}}$				**-0.012**		
				(-1.60)		
Full-load hours$_{\mathbf{instr.}}$						**-1.00*** **
						(-5.41)
Size	1.71***	0.086***	6.34***	0.12**	0.023**	0.068***
	(4.73)	(4.70)	(6.10)	(2.51)	(2.18)	(5.34)
Profitability	9.34*	0.18	30.1**	0.34	0.016	-0.0095
	(1.92)	(1.22)	(2.25)	(1.41)	(0.10)	(-0.053)
Tangibility	-3.30	-0.0065	-8.76	-0.050	0.058	0.12
	(-0.95)	(-0.073)	(-0.74)	(-0.31)	(0.57)	(1.33)
Market-to-book	0.37**	0.021***	0.87	0.023**	0.0077**	0.020**
	(2.56)	(3.22)	(1.29)	(2.51)	(2.33)	(2.02)
Dividend payout	0.041	-0.051**	1.56	-0.024	-0.0077	-0.052*
	(0.034)	(-2.12)	(0.40)	(-0.60)	(-0.28)	(-1.76)
Observations	482	482	482	482	482	482
Year-fixed effects	yes	yes	yes	yes	yes	yes
K-P rk Wald F statistic	36.64		4.23		30.37	
Hansen J p-value	0.47		0.72		0.89	

Models a (b) show the outcome of a first (second) stage IV regression. In models a (b), the flexibility measures (LEVERAGE) are the dependent variables. The sample is restricted to the U.S. firms. Variations in coal, gas, and oil reserves across U.S. states are used as instruments. Independent variables are lagged by one period in the second-stage regressions. K-P stands for Kleibergen-Paap (see Kleibergen and Paap, 2006). T-statistics based on Huber/White robust standard errors clustered by firms and U.S. states are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Appendix A.

Table 10: Access to capital & run-up time

Model	I	II	III	IV	V	VI	VII
Country variable (CV)	Common Law	ASI	Liability	Disclosure	Protection	Access	Non-zero
Run-up time	-0.020***	-0.014***	-0.012***	-0.012***	-0.012***	-0.021***	-0.013***
	(-7.33)	(-2.72)	(-3.95)	(-4.05)	(-3.20)	(-7.56)	(-5.73)
Run-up time x CV	**0.011***	**0.011**	**0.014****	**0.024****	**0.011****	**0.026*****	**0.00023*****
	(1.90)	**(0.63)**	**(2.54)**	**(2.41)**	**(2.12)**	**(3.11)**	**(2.66)**
Size	0.059**	0.063***	0.060***	0.060***	0.060**	0.058***	0.059**
	(2.56)	(2.74)	(2.59)	(2.60)	(2.57)	(2.77)	(2.55)
Profitability	-0.16	-0.16*	-0.15	-0.15	-0.15	-0.14	-0.16
	(-1.62)	(-1.73)	(-1.52)	(-1.52)	(-1.51)	(-1.47)	(-1.61)
Tangibility	0.059	0.017	0.057	0.057	0.058	0.046	0.063
	(0.76)	(0.20)	(0.72)	(0.71)	(0.73)	(0.58)	(0.78)
Market-to-book	0.0047	0.012*	0.0049	0.0049	0.0050	0.0046	0.0042
	(0.94)	(1.73)	(0.96)	(0.95)	(1.00)	(0.93)	(0.81)
Dividend payout	-0.0018	-0.016	-0.0025	-0.0026	-0.0022	-0.0013	-0.0026
	(-0.071)	(-0.57)	(-0.094)	(-0.096)	(-0.081)	(-0.049)	(-0.11)
Observations	708	722	688	688	688	688	701
Adjusted R^2	0.13	0.12	0.13	0.13	0.12	0.14	0.13
Year-fixed effects	yes	yes	yes	yes	yes	yes	yes
Country-fixed effects	yes	yes	yes	yes	yes	yes	yes
Firm-fixed effects	yes	yes	yes	yes	yes	yes	yes

The dependent variable is LEVERAGE. CV stands for country-variable, which is defined separately for each column. Estimation models are firm-fixed effects regressions. The sample is restricted to firms located in countries in which a competitive wholesale market for electricity exists since 2002. All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms and countries are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Appendix A.

Table 11: Event returns around Lehman Brothers collapse

Model	Ia	Ib	Ic	IIa	IIb	IIc
Run-up time	**-0.0053*****			**-0.0044*****		
	(-3.22)			**(-2.88)**		
Ramp-up cost		**-0.00092***			**-0.00078***	
		(-1.81)			**(-1.85)**	
Full-load hours			**-0.17***			**-0.13**
			(-1.99)			**(-1.62)**
Leverage	-0.014	-0.0097	-0.016	-0.012	-0.0029	-0.016
	(-0.32)	(-0.21)	(-0.34)	(-0.33)	(-0.084)	(-0.37)
Size	0.0097**	0.0086**	0.0083*	0.0060	0.0044	0.0043
	(2.25)	(2.30)	(1.72)	(1.23)	(0.93)	(0.83)
Free float [%]	-0.00050**	-0.00047*	-0.00053**			
	(-2.08)	(-1.97)	(-2.04)			
Profitability				0.14	0.14	0.16*
				(1.63)	(1.60)	(1.70)
Tangibility				0.026	0.021	0.033
				(0.78)	(0.67)	(0.92)
Market-to-book				-0.00082	-0.0015	-0.00087
				(-0.19)	(-0.35)	(-0.20)
Dividend payout				0.0022	0.0049	0.0037
				(0.054)	(0.12)	(0.089)
Observations	272	272	272	307	307	307
Adjusted R^2	0.31	0.29	0.30	0.34	0.33	0.33
Year-fixed effects	yes	yes	yes	yes	yes	yes
Country-fixed effects	yes	yes	yes	yes	yes	yes

The dependent variable is the cumulative abnormal return around September 15^{th}, 2008 with an event window of [-3,3] trading days. The estimation methodology is described in Section 5.1. All models are pooled-OLS regressions. All independent variables are as of 2007. T-statistics based on Huber/White robust standard errors clustered by countries are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Appendix A.

Table 12: Electricity price volatility

Model	I	II	III
Run-up time	-0.015***		
	(-3.45)		
Run-up time x Volatility	**-0.024****		
	(-2.41)		
Ramp-up cost		-0.0034**	
		(-2.39)	
Ramp-up cost x Volatility		**-0.0062*****	
		(-2.65)	
Full-load hours			-0.39
			(-1.41)
Full-load hours x Volatility			**-1.38*****
			(-3.04)
Volatility	0.054	0.074	0.087
	(0.63)	(1.19)	(1.15)
Size	0.049**	0.047**	0.047**
	(2.20)	(2.08)	(2.11)
Profitability	-0.069	-0.072	-0.075
	(-0.48)	(-0.51)	(-0.52)
Tangibility	0.15	0.15	0.15
	(1.12)	(1.12)	(1.17)
Market-to-book	0.0050	0.0063	0.0061
	(0.75)	(0.97)	(0.94)
Dividend payout	-0.035	-0.029	-0.029
	(-1.34)	(-1.16)	(-1.15)
Observations	670	670	670
Adjusted R^2	0.12	0.12	0.11
Year-fixed effects	yes	yes	yes
Country-fixed effects	yes	yes	yes
Firm-fixed effects	yes	yes	yes

The dependent variable is LEVERAGE. All estimation models are firm-fixed effects regressions. The variables which are interacted are centered. Volatility, i.e., the volatility of hourly electricity prices over a firm's fiscal year is interacted with the firm's production flexibility over the same time period. All other independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms and regions (i.e., electricity markets) are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Appendix A.

Figure 1: Sample countries (grey)

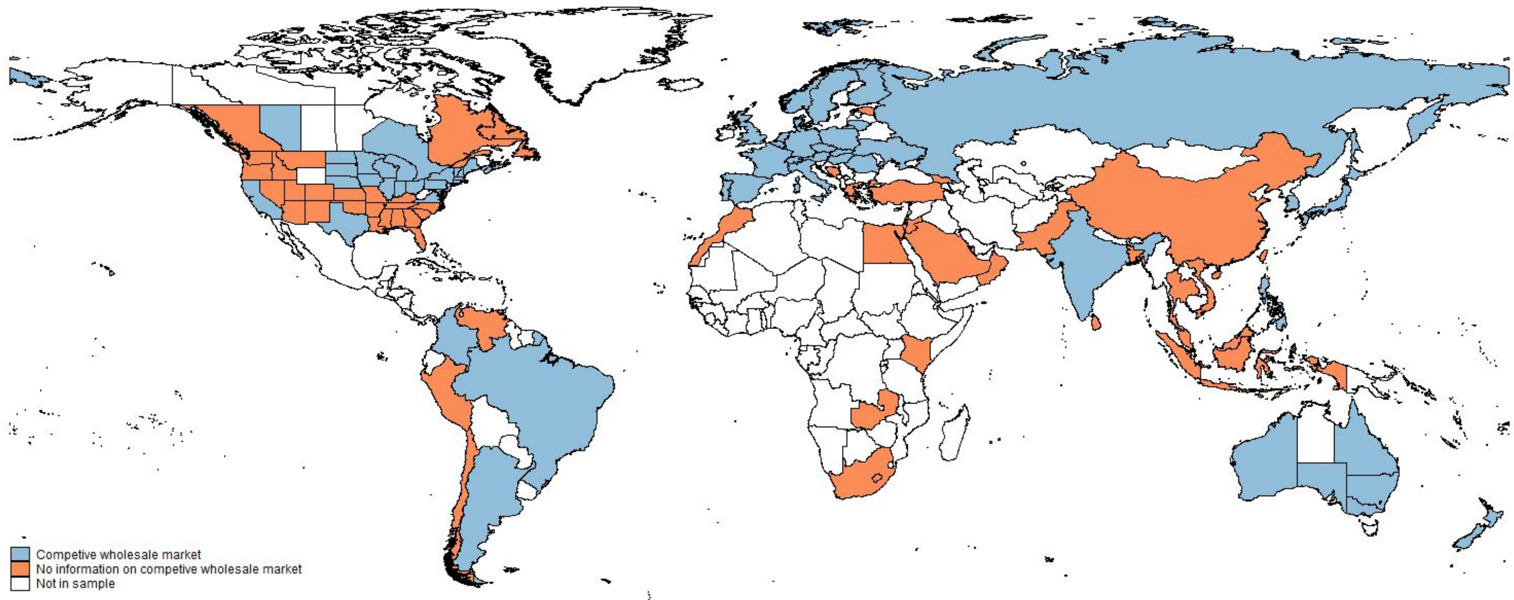

Figure 2: Competitive wholesale markets for electricity

Appendix

Appendix A: Definition of variables

Variable	Description
Main variables	
Run-up time	Average time necessary to start-up a power plant. Measured in hours. Based on the production technologies of the firms' power plants. Source: Own calculations based on the Platts WEPP database.
Ramp-up cost	Average cost for a hot start of power plant. Measured in €/MW. Based on the production technologies of the firms' power plants. Source: Own calculations based on the Platts WEPP database.
Full-load hours	Average fraction of full-load hours. Measured as average yearly full-load hours divided by 8760 hours per year. Based on the production technologies of the firms' power plants. Source: Own calculations based on the Platts WEPP database.
Leverage	Total debt [wc03255] / (Total debt [wc03255] + book value of common equity [wc03501])
Control variables	
Size	Natural logarithm of the firm's total assets [wc029999] in U.S. dollar
Profitability	Earnings before interest, taxes, depreciations, and amortizations (EBITDA) [wc18198] / total assets [wc02999]
Tangibility	Property, plant and equipment [wc02501] / total assets [wc02999]
Market-to-book	Market capitalization [wc08001] / book value of common equity [wc03501]
Dividend	Dummy variable which equals one if the firm pays a dividend [wc05376] and zero otherwise
Investor protection measures	
Common	Dummy variable which equals one for common law countries and zero otherwise. Source: McLean et al. (2009).
Anti-self	Anti-self dealing index. Source: Djankov et al. (2008).
Liability	Index of the liability standards in a country. Source: LaPorta et al. (2006).
Disclosure	Index of the disclosure standards in a country. Source: LaPorta et al. (2006).
Protect	LaPorta et al. (2006) define this as the principal component of the indices of disclosure requirements, liability standards, and anti-director rights. Source: McLean et al. (2012) based on LaPorta et al. (2006).
Access	Survey-based index measuring how easy it is for firms to issue equity. Source: McLean et al. (2012) based on Schwab et al. (1999).
Non-zero	Percentage of month in a country in which firms issued or repurchased shares. Source: McLean et al. (2009).

Definition of Variables - continued

Variable	Description
Other variables	
Gas price	Price of natural gas for electricity generation in a U.S. state. Measured in U.S. dollar per thousand Cubic Feet. Source: Energy Information Association (EIA).
Electricity price	Yearly average electricity price on a specific power exchange. Measured in U.S. dollar per megawatt hour. Source: Electricity exchanges & Datastream.
Coal reserves	Recoverable coal reserves at producing mines in 1995. Measured in billion short tons. Source: EIA, Coal Industry Report 1995.
Gas reserves	Dry natural gas proved reserves in 1995. Measured in trillion cubic feet. Source: EIA, U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves 1996 Annual Report.
Oil reserves	Crude oil proved reserves in 1995. Measured in billion barrels of 42 U.S. gallons. Source: EIA, U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves 1996 Annual Report.
Public ownership	Dummy variable which equals one if the state or a federal entity are among the three largest shareholders in a specific year and zero otherwise. Source: Thomson Reuters Global Ownership database.
Market leverage	Total debt [wc03255] / (Total debt [wc03255] + book value of common equity [wc08001])
Long-term book lev.	Long term debt [wc03251] / (Total debt [wc03255] + book value of common equity [wc03501])
Net book leverage	Long term debt [wc03251]-Cash and short term investments [wc02001] / (Total debt [wc03255] + book value of common equity [wc03501])
Free float [%]	Percentage of total shares available to ordinary investors [noshff]. Source: Datastream
Asset age	Calculated as the capacity-weighted average age of the firm's assets in the respective year. Source: Own calculations based on the Platts WEPP database.
Regional diversification	Equals one if company has power plants in more than one country and zero otherwise. Source: Own calculations based on the Platts WEPP database.
Volatility	Volatility of the hourly electricity spot price of the firm's fiscal year.

Appendix B: Production technologies

Technology	**Run-up time** in hours		**Ramp-up costs** in €/MW		**Full-load hours** in hours/year	
Biogas	0.25	B	32.22	Z	3170	Z
Biomass	2.00	B	46.96	Z	5000	G
Coal	3.00	A	46.96	F	3550	G
Hydro	0.08	E	0.00	Z	3510	G
Gas	0.25	C	25.45	Z	1640	Z
Gas combined-cycle	1.50	A	32.22	E	3170	G
Geothermal	0.00	Z	0.00	Z	5000	Z
Lignite	6.00	A	35.75	F	6640	G
Nuclear	40.00	A	132.92	F	7710	G
Oil	0.08	D	25.45	F	1640	G
Pump storage	0.02	E	0.00	Z	970	G
Solar	0.00	Z	0.00	Z	910	G
Waste	12.00	B	46.96	Z	5000	Z
Wind	0.00	Z	0.00	Z	1550	G

Run-up time is measured in hours and refers to warm-starts in the case of thermal power plants. They are based on Eurelectric's "Flexible Generation: Backing-up Renewables", p. 19, (marked with A), Danish Energy Agency's "Technology Data for Energy Plants" (B) and Swider (2006) (C). The run-up time of oil power plants is based on company websites, e.g., life-cycle power solutions provider Wärtsilä (D). The values for hydro and pump storage power plants are based on data from Duke Energy, FirstGen, and MWH Global (E). We also have to make some assumptions (marked with Z). The run-up time for solar and wind is zero, as such plants are usually not actively dispatched and start generation as soon as sun or wind are available. Similarly, we assume a run-up time of zero for geothermal power plants.

Ramp-up costs are measured in €/MW and are mainly based on Boldt et al. (2012) (marked with F). We also have to make some assumptions (Z). In particular, we assume that ramp-up costs for gas power plants equal those of oil power plants. Further, we assume zero ramp-up costs for geothermal, hydro, pump storage, solar, and wind power plants. For biomass and waste power plants we assume equal ramp-up costs as for flexible coal power plants. For biogas we assume the same cost as for gas combined cycle.

Full-load hours are average full-load hours per year. They are mostly based on the Federal Statistical Office of Germany (marked with G). The values refer to full-load hours of German power plants in 2007. We assume that full-load hours of gas plants equal those of oil plants. Furthermore, we assume that waste, and geothermal power plants have similar full-load hours as biomass plants and that full-load hours of biogas plants equal those of gas combined cycle plants (Z).

Appendix C. Variable construction example

This section provides an example how to calculate the main variables. For the following example, we assume that we matched the following power plants to the energy utility X in 2008:

Plant	**Capa**	**Technology**	**COD**	**Run-up**	**Ramp-up**	**Full-load hours**	
Name	MW	n/a	year [y]	hours [h]	€/MW	yearly	fraction
A	6	Wind	2006	0	0	1550	0.18
B	100	Biomass	1990	2.00	46.96	5000	0.57
C	2,000	Nuclear	1980	40.00	132.92	7710	0.88
D	1,000	Gas	1975	0.25	32.22	3170	0.36
E	1,500	Gas	1990	0.25	32.22	3170	0.36

First, run-up time is defined as the average run-up time of all power plants in the company's portfolio. Each power plant is weighted by its capacity. The run-up time of each power plant is based on its technology and defined in Table Appendix B. Thus, the variable RUN-UP TIME for firm X in 2008 is calculated as follows:

$$\begin{aligned}
\textsc{Run-up time}_X &= \frac{\sum_{k=1}^{M} \text{Capacity}_k \cdot \text{Run-up time}_k}{\text{Total capacity}} \\
&= \frac{(6 \cdot 0 + 100 \cdot 2 + 2,000 \cdot 40 + (1,000 + 1,500) \cdot 0.25)\text{MW} \cdot h}{(6 + 100 + 2,000 + 1,000 + 1,500)\text{MW}} \\
&= \frac{80,825\text{MW} \cdot h}{4,606\text{MW}} = 17.55h
\end{aligned}$$

Second, RAMP-UP COSTS are calculated in the same way as run-up time. The only difference is that ramp-up costs are used in the above formula instead of run-up times.

$$
\begin{aligned}
\textsc{Ramp-up costs}_X &= \frac{\sum_{k=1}^{M} \text{Capacity}_k \cdot \text{Ramp-up costs}_k}{\text{Total capacity}} \\
= &\quad \frac{(6 \cdot 0 + 100 \cdot 46.96 + 2,000 \cdot 132.92 + (1,000 + 1,500) \cdot 32.22)\text{MW} \cdot €/MW}{(6 + 100 + 2,000 + 1,000 + 1,500)\text{MW}} \\
= &\quad \frac{351,086\text{MW} \cdot €/MW}{4,606\text{MW}} = 76.22€/\text{MW}
\end{aligned}
$$

Third, FULL-LOAD HOURS are calculated. For this, we apply the fraction of full-load hours, which is calculated as yearly full-load hours divided by 8760 hours per year.

$$
\begin{aligned}
\textsc{Full-load hours}_X &= \frac{\sum_{k=1}^{M} \text{Capacity}_k \cdot \text{Full-load hours}_k}{\text{Total Capacity}} \\
= &\quad \frac{(6 \cdot 0.18 + 100 \cdot 0.57 + 2,000 \cdot 0.88 + (1,000 + 1,500) \cdot 0.36)\text{MW}}{(6 + 100 + 2,000 + 1,000 + 1,500)\text{MW}} \\
= &\quad \frac{2718.08\text{MW}}{4,606\text{MW}} = 0.59
\end{aligned}
$$

Fourth, we calculate ASSET AGE. We average the start year of commercial operation of all power plants. Again, we weight the individual start year of each plant by its capacity. As we require the average asset age for each sample year, we subtract the average start year from the reference year. Thus, the variable ASSET AGE for firm X in 2008 is calculated as follows:

$$
\begin{aligned}
\textsc{asset age}_X &= \text{Year of observation} - \frac{\sum_{i=1}^{N} \text{Capacity}_i \cdot \text{Year}_i^{Start}}{\text{Total capacity}} \\
= &\quad 2008y - \frac{(6 \cdot 2006 + 100 \cdot 1990 + 2,000 \cdot 1980 + 1,000 \cdot 1975 + 1,500 \cdot 1990)y}{(6 + 100 + 2,000 + 1,000 + 1,500)\text{MW}} \\
= &\quad 2008y - \frac{9,131,036y \cdot \text{MW}}{4,606\text{MW}} = 25,58y
\end{aligned}
$$

Appendix 1: Robustness test: public ownership

Model	I	II	III
Run-up time	**-0.0081*** **		
	(-3.21)		
Ramp-up cost		**-0.0017** **	
		(-2.05)	
Full-load hours			**-0.17** **
			(-2.05)
State ownership	**-0.012**	**-0.012**	**-0.012**
	(-0.60)	**(-0.59)**	**(-0.56)**
Size	0.093***	0.092***	0.093***
	(5.25)	(5.31)	(5.20)
Profitability	-0.25***	-0.25***	-0.25***
	(-3.47)	(-3.57)	(-3.49)
Tangibility	0.10	0.10	0.099
	(1.56)	(1.57)	(1.52)
Market-to-book	0.010**	0.011**	0.011**
	(2.21)	(2.22)	(2.24)
Dividend payout	-0.043**	-0.044**	-0.043**
	(-2.41)	(-2.45)	(-2.41)
Observations	2,034	2,034	2,034
Adjusted R^2	0.14	0.14	0.14
Year-fixed effects	yes	yes	yes
Country-fixed effects	yes	yes	yes
Firm-fixed effects	yes	yes	yes

The dependent variable is LEVERAGE. A dummy variable indicating if the state or a federal entity are among the three largest shareholders in a specific year is included in all models. All estimation models are firm-fixed effects regressions. All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Appendix A.

Appendix 2: Robustness test: excluding technologies

Model	Ia	Ib	Ic	Id	Ie	IIa	IIb	IIc	IId	IIe
Exclusion	Coal	Gas	Nuclear	Oil	R/W/S	Coal	Gas	Nuclear	Oil	R/W/S
Ramp-up cost	**-0.0015****	**-0.0015***	**-0.0018*****	**-0.0013****	**-0.0029*****					
	(-2.13)	**(-1.87)**	**(-3.09)**	**(-2.00)**	**(-3.20)**					
Full-load hours						**-0.23**	**-0.32****	**-0.15**	**-0.15**	**-0.17**
						(-1.64)	**(-2.04)**	**(-1.58)**	**(-1.16)**	**(-1.19)**
Size	0.071***	0.093***	0.080***	0.067***	0.085***	0.073***	0.094***	0.081***	0.068***	0.085***
	(3.04)	(4.35)	(4.44)	(2.66)	(2.93)	(3.12)	(4.35)	(4.44)	(2.69)	(2.93)
Profitability	-0.22**	-0.23**	-0.31***	-0.16	-0.44**	-0.22**	-0.23**	-0.31***	-0.16	-0.43**
	(-2.03)	(-2.48)	(-3.30)	(-1.41)	(-2.06)	(-2.05)	(-2.52)	(-3.30)	(-1.41)	(-2.03)
Tangibility	0.14*	0.27***	0.15**	0.20**	0.079	0.14	0.26***	0.14**	0.20**	0.069
	(1.72)	(2.91)	(2.33)	(2.24)	(0.86)	(1.61)	(2.83)	(2.27)	(2.19)	(0.76)
Market-to-book	0.0057	0.0080**	0.0057*	0.0034	0.0024	0.0057	0.0079**	0.0058*	0.0037	0.0023
	(1.37)	(2.28)	(1.91)	(0.68)	(0.37)	(1.37)	(2.31)	(1.96)	(0.73)	(0.35)
Dividend payout	-0.044*	-0.056**	-0.039**	-0.068***	-0.048**	-0.043*	-0.053**	-0.038**	-0.067***	-0.051**
	(-1.85)	(-2.19)	(-2.32)	(-2.68)	(-2.22)	(-1.76)	(-2.08)	(-2.27)	(-2.64)	(-2.28)
Observations	935	789	1,548	857	604	935	789	1,548	857	604
Adjusted R^2	0.091	0.14	0.12	0.12	0.18	0.092	0.14	0.12	0.11	0.18
Year-fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country-fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm-fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

The dependent variable is LEVERAGE. Firms owning power plants with certain technologies are excluded. For example, only firms that do not own coal-fired power plants are included in model I. H/W/S stands for hydro/wind/solar. Estimation models are firm-fixed effects regressions. All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Appendix A.

Appendix 3: Robustness test: other production variables

Model	I	II	III
Run-up time	**-0.0087*** **		
	(-3.42)		
Ramp-up cost		**-0.0019** **	
		(-2.39)	
Full-load hours			**-0.18***
			(-1.91)
Asset age	-0.0010	-0.0011	-0.00053
	(-1.42)	(-1.50)	(-0.78)
Regional diversification	0.0076	0.0086	0.0073
	(0.53)	(0.58)	(0.49)
Size	0.099***	0.098***	0.100***
	(6.29)	(6.34)	(6.22)
Profitability	-0.26***	-0.26***	-0.26***
	(-3.32)	(-3.37)	(-3.34)
Tangibility	0.098*	0.099*	0.098*
	(1.80)	(1.81)	(1.78)
Market-to-book	0.012***	0.012***	0.012***
	(2.98)	(2.97)	(3.02)
Dividend payout	-0.033**	-0.034**	-0.033**
	(-2.06)	(-2.11)	(-2.05)
Observations	2,222	2,222	2,222
Adjusted R^2	0.16	0.15	0.15
Year-fixed effects	yes	yes	yes
Country-fixed effects	yes	yes	yes
Firm-fixed effects	yes	yes	yes

The dependent variable is LEVERAGE. All Estimation models are firm-fixed effects regressions. All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Appendix A.

Appendix 4: Robustness test: leverage definition

Model	Ia	Ib	Ic	IIa	IIb	IIc	IIIa	IIIb	IIIc
		market leverage			long-term book leverage			net book leverage	
Run-up time	**-0.0054***			**-0.0077*****			**-0.0096*****		
	(-1.95)			**(-3.34)**			**(-2.75)**		
Ramp-up cost		**-0.0013**			**-0.0017****			**-0.0021***	
		(-1.56)			**(-2.30)**			**(-1.75)**	
Full-load hours			**-0.19****			**-0.071**			**-0.22****
			(-2.07)			**(-0.92)**			**(-2.26)**
Size	0.11***	0.069***	0.12***	0.11***	0.068***	0.12***	0.11***	0.069***	0.12***
	(6.04)	(5.14)	(5.47)	(6.08)	(5.24)	(5.56)	(6.03)	(5.05)	(5.44)
Profitability	-0.36***	-0.18***	-0.43***	-0.36***	-0.19***	-0.43***	-0.36***	-0.19***	-0.43***
	(-4.00)	(-3.30)	(-3.94)	(-4.03)	(-3.38)	(-3.99)	(-4.01)	(-3.30)	(-3.95)
Tangibility	0.034	0.11**	0.22***	0.035	0.11**	0.22***	0.033	0.11**	0.21***
	(0.61)	(2.05)	(2.71)	(0.62)	(2.06)	(2.72)	(0.58)	(2.03)	(2.68)
Market-to-book	-0.0032	0.0064*	0.012**	-0.0031	0.0064*	0.012**	-0.0029	0.0066*	0.012**
	(-0.79)	(1.89)	(2.36)	(-0.78)	(1.90)	(2.35)	(-0.74)	(1.95)	(2.40)
Dividend payout	-0.026	-0.017	-0.017	-0.027	-0.017	-0.018	-0.026	-0.017	-0.017
	(-1.61)	(-1.28)	(-0.79)	(-1.63)	(-1.32)	(-0.82)	(-1.57)	(-1.32)	(-0.78)
Observations	2,248	2,250	2,239	2,248	2,250	2,239	2,248	2,250	2,239
Adjusted R^2	0.27	0.097	0.14	0.27	0.097	0.14	0.27	0.091	0.13
Year-fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country-fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm-fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes

The dependent variable is MARKET LEVERAGE in model I, LONG-TERM BOOK LEVERAGE in model II, and NET BOOK LEVERAGE in model III. All estimation models are firm-fixed effects regressions. All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Appendix A.

Appendix 5: Causality: first stage results

Model	Ia	Ib	Ic	IIa	IIb	IIc	IIIa	IIIb	IIIc
Sample		Full			Excl. U.S. / Japan			Europe	
Run-up time$_{1995}$	**0.91***** **(31.9)**			**0.94***** **(26.0)**			**0.99***** **(20.0)**		
Ramp-up cost$_{1995}$		**0.85***** **(31.8)**			**0.88***** **(29.6)**			**0.95***** **(16.9)**	
Full-load hours$_{1995}$			**0.76***** **(15.1)**			**0.79***** **(15.6)**			**0.93***** **(12.4)**
Size	0.14**	0.61*	0.0052**	0.087	0.19	0.0038	0.094	0.22	0.0066
	(2.14)	(1.78)	(2.14)	(1.37)	(0.63)	(1.43)	(0.54)	(0.34)	(1.25)
Profitability	-0.33	0.59	0.014	-1.13	-4.05	-0.013	-1.65	-4.74	0.035
	(-0.39)	(0.14)	(0.50)	(-1.25)	(-0.88)	(-0.44)	(-1.07)	(-1.00)	(0.71)
Tangibility	0.31	-3.72	0.011	-0.030	-5.19*	-0.0027	1.46	4.16	0.089**
	(0.66)	(-1.54)	(0.53)	(-0.071)	(-1.92)	(-0.11)	(1.44)	(1.11)	(2.07)
Market-to-book	0.0070	-0.22	0.0021	-0.0082	-0.26	0.0011	0.066	0.36	-0.0024
	(0.19)	(-0.82)	(1.26)	(-0.20)	(-0.88)	(0.58)	(0.50)	(0.74)	(-0.62)
Dividend payout	0.087	0.79	0.0059	0.094	0.44	0.0014	0.050	1.16	0.0096
	(0.56)	(0.96)	(1.03)	(0.68)	(0.44)	(0.22)	(0.11)	(0.79)	(0.62)
Observations	1,505	1,505	1,505	962	962	962	177	177	177
Year-fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country-fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes

This table depicts the outcome of a first-state IV regression. Values as of 1995 are used as instruments for the flexibility measures. The dependent variable are RUN-UP TIME, RAMP-UP COST, and FULL-LOAD HOURS. In model II, firms located in the U.S. and Japan are excluded. Only firms that are located in European countries which introduced electricity power exchanges between 1995 and 2003 are included in model III. Furthermore, model III includes only observations after 2004. T-statistics based on Huber/White robust standard errors clustered by firms are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Appendix A.

Appendix 6: Robustness test: alternative event window

Model	Ia	Ib	Ic	IIa	IIb	IIc
Run-up time	**-0.0034*** **			**-0.0028*** **		
	(-5.39)			**(-4.80)**		
Ramp-up cost		**-0.00076** **			**-0.00061** **	
		(-2.25)			**(-2.63)**	
Full-load hours			**-0.079**			**-0.057**
			(-1.60)			**(-1.18)**
Leverage	0.010	0.010	0.013	0.023	0.027	0.025
	(0.35)	(0.35)	(0.46)	(1.00)	(1.26)	(0.96)
Size	0.00045	0.00053	-0.0012	0.00037	-0.000077	-0.0014
	(0.17)	(0.30)	(-0.37)	(0.12)	(-0.026)	(-0.41)
Free float [%]	-0.00014	-0.00013	-0.00014			
	(-0.85)	(-0.78)	(-0.77)			
Profitability				0.060	0.065	0.067
				(1.20)	(1.41)	(1.22)
Tangibility				-0.0058	-0.0087	-0.0030
				(-0.18)	(-0.26)	(-0.085)
Market-to-book				-0.0019	-0.0023	-0.0020
				(-0.62)	(-0.76)	(-0.64)
Dividend payout				0.0078	0.0095	0.0089
				(0.29)	(0.35)	(0.33)
Observations	272	272	272	307	307	307
Adjusted R^2	0.15	0.14	0.12	0.20	0.20	0.19
Year-fixed effects	yes	yes	yes	yes	yes	yes
Country-fixed effects	yes	yes	yes	yes	yes	yes

The dependent variable is the cumulative abnormal return around September 15^{th}, 2008 with an event window of [-1,2] trading days. The estimation methodology is described in Section 5.1. All models are pooled-OLS regressions. All independent variables are as of 2007. T-statistics based on Huber/White robust standard errors clustered by countries are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Appendix A.

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