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Simple valuation of electric utilities – a comparison of the residual income model and a real options approach

Abstract

Since deregulation of the energy market in Norway, there has been a number of mergers and acquisitions of electric utilities. In all these transactions, the companies have been valued. Many of the transactions have sparked significant controversy (by politicians, consultants and others) who claim that the companies have been sold too cheaply, especially concerning hydropower generating companies. How can business valuation of these enterprises be explained? Real option theory is, in this study, applied in order to explain the value beyond a traditional approach. The residual income model proposed by Feltham and Ohlson (1995) is considered.

The empirical analysis shows that an enhancement in explanatory power of 100% is brought about through the introduction of independent variables based on real option theory. This supports the use of real options in helping to explain values in this industry.

Keywords: real options, residual income valuation, generating companies, business valuation.
JEL Classification: C12, C20, D46, G34.

Introduction

Real option valuation represents a relatively new and innovative approach to valuing assets and companies. The concept of real options is an extension of financial options applied to real projects and business valuation. Even if option-pricing techniques were initially viewed as rather arcane and specialized financial instrument, the researchers behind this development recognized early on the potential for applying the same type of approach to a variety of other valuation problems (Merton, 1998). Myers introduced the term “real options” in 1977 (Myers, 1977). During the last 40 years, much research has been carried out in the field of applying option pricing theory to valuing real assets (Amram and Kulatilaka, 1999; Antikarov and Copeland, 2003; Dixit and Pindyck, 1994; Mun, 2002; Trigeorgis, 1996). Real options have been termed a “new paradigm” and a “revolution” (Antikarov and Copeland, 2003; Schwartz and Trigeorgis, 2001).

Still, there are far more theoretical and conceptual articles than empirical studies in the academic literature on the subject. Although real options have been widely presented in corporate finance literature, academic journals and in financial books, implementations by professionals in business are still limited in numbers (Horn et al., 2015). This paradox has been debated (Copeland and Tufano, 2004; Philippe, 2005b; Sick, 2002; Teach, 2003). Hence, studies that can empirically test the relevance of real option theory may be of considerable interest (Schwartz and Trigeorgis, 2001). The empirical studies like Paddock, Siegel and Smith (1988), Baily (1991), Quigg (1993, 1995) and Moel and Tufano (2000) are, therefore, much quoted within real option literature (Philippe, 2005a; Trigeorgis and Schwartz, 2001). There have been more empirical studies in the last decade (see, e.g., the list in Fernandes, Cunha and Fereira, 2011); however, there is still a call for more empirical studies in order to verify real options as something consistent with investment behavior and implemental for practitioners, especially concerning business valuation.

The most popular sector for real option application is the energy industry, including the Nordic hydropower based electricity generation industry (e.g., Bøchman et al., 2008; Kjærland, 2007). The deregulation of this industry (in early 1990) led on to an emerging new market of tradable electric utilities, especially generating companies. Public owners still control the vast majority of generating capacity. However, in the post-deregulation period, there have been many transactions, in which electric utilities have been involved in mergers or acquisitions. All these transactions have included assessment of the value of the companies involved, creating a need for qualified calculation of business value. Most of these companies were not traded on the stock exchange, limiting the access to value relevant information and complicating business value calculations. Many of the transactions have sparked controversy with several observers (politicians, consultants and others) who claim that the companies have been sold too cheaply. Hence, this industry is especially suitable as the empirical setting for this study.

The focus of this paper is to analyze transactions involving Norwegian generating companies during the post deregulation period, and to test a conventional valuation model and an extended model based on real option theory. The purpose is,

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then, to test whether introducing option components increases the explanatory power of the valuation model. The intension is to deepen the understanding of the value, and the value components of these enterprises. The following research questions arise:

1. How can the value of Norwegian electricity generating companies be explained?
2. Can real options enhance explanation of value compared to traditional valuation models?

This study makes use of the residual income model developed by Ohlson (1995) and Feltham and Ohlson (1995) as the benchmark model for valuing the companies. The residual income model framework is one version of a classical valuation model, and is in line with several papers published regarding company valuation (Frankel and Lee, 1998). Access to accounting data makes this a convenient approach. The model is used to perform benchmark valuation before introducing option-related variables. Ultimately, this enables a comparison of the two models.

The rest of the paper is organized as follows: first, the residual income model and the research design are presented. Then, the empirical model is presented. Hypothesized links between dependent and independent variables are derived as well. The sample, data and results are, then, summarized, and, finally, conclusions, implications and limitations are reported.

1. The residual income model and research design

The market value of firms is commonly defined as the discounted present value of expected net cash flow using an appropriate discount rate reflecting the relevant risk. Forecasts of future revenues, expenses, earnings and cash flow form the crux of the valuation (Kothari, 2001; Miller and Modigliani, 1961). Lee (1999, p. 414) even concludes that the "essential task in valuation is forecasting. It is the forecast that breathes life into a valuation model". Dominant valuation models are the cash flow model and the dividend model. But there are other alternatives, such as the residual income (RI) model developed by Feltham and Ohlson (1995). Theoretically, there is equivalence between the various models (Feltham and Christensen, 2003; Fernández, 2007; Penman, 1997). They all yield the same fundamental value of companies when applied properly and consistently. The residual income valuation model expresses value as the sum of current book value and the discounted present value of expected abnormal earnings, defined as forecasted earnings minus a capital charge equal to the forecasted book value times the discount rate. One version of the RI model is:

$$V_t = BV_t + \sum_{i=1}^{\infty} \frac{E_t\left[NI_{t+i} - (r_e \cdot BV_{t+i-1})\right]}{\left(1+r_e\right)^i} = \\ = BV_t + \sum_{i=1}^{\infty} \frac{E_t\left[\left(ROE_{t+i} - r_e\right) \cdot BV_{t+i-1}\right]}{\left(1+r_e\right)^i}, \quad (1)$$

in which V_t is value at time t, BV_t is book value at time t, $E_t[\cdot]$ is expectation based on available information at time t, NI_{t+i} is the net income for period $t+i$, r_e is the capital charge of equity and ROE_{t+i} is the after-tax return on book equity for period $t+i$.

If equation (1) is divided by BV_t, an expression for the price-to-book ratio materializes. The electricity industry, as a mature industry, could be characterized by low residual income. Nevertheless, there are so many uncertain characteristics in the industry that make it reasonable to believe that a significant part of the business value, in this industry, should lie in the second component, i.e., in future growth opportunities. These uncertain aspects are associated with the volatility of electricity prices, the uncertainty of the market due to political and environmental concerns, constraints in transmission capacity and the prices of oil, gas and coal.

Model 1. The first step in the methodological part of the study is to establish a benchmark model for valuing electric utilities. The purpose of this study is to test the incremental impact of independent "real option" variables enabling use of a simplified basic model as benchmark. The design is inspired by Beaver et al. (1989) (banking industry), Bowen (1981) (electric utility industry), Bernard and Ruland (1987) and Jennings (1990). The model for the value at time t can be expressed as follows:

$$V_t = BV_t + RI_t + GO_t + u_t, \quad (2)$$

where BV_t is book value at time t, RI_t is the net present value of expected future residual income at time t, ignoring growth options, GO_t is a proxy for the value of growth options at time t and u_t is the error term in the model. The two first terms in the equation make up the benchmark model, estimating the value of assets-in-place and predictable growth. This part includes expected growth, as performed in traditional valuation. The third term is supposed to capture the potential value of real options not captured by earnings based on assets-in-place (included predictable growth). This is discussed in more detail later.

The benchmark model gives an estimate of the intrinsic value of assets-in-place based on certain input parameters: 1) current book value, 2) cost of equity capital and 3) estimated future *ROE*. To determine these parameter values, we make some considerations found in Table 1.

Table 1. Input parameters in the model

BOOK VALUE (BV)	Book value of equity is obtained from the most recent annual accounting report before the transaction.
COST OF EQUITY CAPITAL (r_e)	The cost of equity after tax can be found by using the CAPM model (Norwegian tax rate of 28% - which is the relevant investor tax rate in this period): $r_e = r_f \cdot (1-0.28) + \beta_i \cdot ERP$, where r_f is the risk free rate, β_i is the equity Beta for the actual company *i*, and *ERP* is the equity risk premium after tax.
RISK FREE RATE (r_f)	Concerning the risk-free rate Gjesdal and Johnsen (1999) recommend 3-year state issued bonds. This study is conducted in a Norwegian context making it natural to follow this recommendation.
BETA (β)	Equity betas of energy producers in Europe are about 0.70 (Lehman Brothers, 2006). Some have implied an even lower beta for hydropower generators. This is due to the inelasticity in demand for power, which does not vary much over the business cycle.
EQUITY RISK PREMIUM (*ERP*)	The equity risk premium is set to 5%. This fits in with the discussion and recommendations presented by Gjesdal and Johnsen (1999).

To forecast future *ROE* is not an easy task. According to Frankel and Lee (1998), two alternatives exist for estimating forecasted *ROE*: historical time series of earnings and analysts' forecasts. Because the current study concerns non-listed companies (with two exceptions), there are no analysts' forecasts available. Hence, the chosen approach is based on historical earnings performance. According to Penman (2013), return is "mean reverting", meaning that it tends to move close to the capital cost over time due to competition and diminishing profitability. On the other hand, studies have shown that current *ROE* is a reasonable estimate for future *ROE* (Fairfield, 1994). The peculiar characteristics of this industry would seem to point to a reliance on historical performance. Nevertheless, several choices need to be made. One is "how many years of data to use in the estimation of future *ROE*?" Forecast horizon and terminal value estimation must also be decided on. The time line follows the illustration in Figure 1. Transaction year is set to *t*. The transactions are spread throughout the year, so the year *t*-1, *t*-2 and *t*-3 are defined as the three fiscal years before the transaction took place. The estimated parameters are for year *t*+1, *t*+2 and *t*+3.

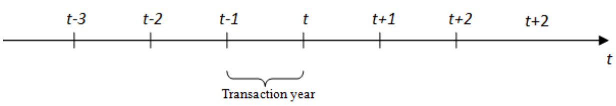

Fig. 1. Time line for the analysis

Estimated future *ROE* based on the average historical *ROE* from the past three years is shown as follows:

$$\hat{ROE}_t = \frac{1}{3}\cdot\left[\frac{NI_{t-3}}{0.5\cdot(BV_{t-4}+BV_{t-3})} + \frac{NI_{t-2}}{0.5\cdot(BV_{t-3}+BV_{t-2})} + \frac{NI_{t-1}}{0.5\cdot(BV_{t-2}+BV_{t-1})}\right], \quad (3)$$

in which *NI* is net income after tax the relevant year and *BV* refers to book value from the balance sheet (end of year). The same lagged procedure is implemented in the estimates of *ROE* during time period *t+1* and *t+2*:

$$\hat{ROE}_{t+1} = \left(\frac{1}{3}\cdot\left(ROE_{t-2} + ROE_{t-1} + \hat{ROE}_t\right)\right)$$

$$\hat{ROE}_{t+2} = \left(\frac{1}{3}\cdot\left(ROE_{t-1} + \hat{ROE}_t + \hat{ROE}_{t+1}\right)\right).$$

The forecast period must be finite. This leads to the need for a terminal value estimate. This terminal value at time *t* becomes:

Terminal value:

$$\frac{(ROE_{T+1} - r_e)}{(1+r_e)^T \cdot (r_e - g)} \cdot BV_T, \quad (4)$$

in which *g* denotes the predictable growth for assets-in-place.

The benchmark model $\hat{V}_t$ is established in three versions, based on different time horizons. The model has a one to three year time horizon (Frankel and Lee, 1998). Using three versions can also serve as a sensitivity check of the benchmark model. The following forms of $\hat{V}_t$ are calculated:

$$\hat{V}^1_t = \hat{BV}_t + \frac{(\hat{ROE}_t - r_e)}{(1+r_e)}\cdot\hat{BV}_t + \frac{(\hat{ROE}_t - r_e)}{(1+r_e)\cdot(r_e-g)}\cdot\hat{BV}_t \quad (5a)$$

$$\hat{V}^2_t = \hat{BV}_t + \frac{(\hat{ROE}_t - r_e)}{(1+r_e)}\cdot\hat{BV}_t + \frac{(\hat{ROE}_{t+1} - r_e)}{(1+r_e)^2}\cdot\hat{BV}_{t+1} + \frac{(\hat{ROE}_{t+1} - r_e)}{(1+r_e)^2\cdot(r_e-g)}\cdot\hat{BV}_{t+1} \quad (5b)$$

$$\hat{V}^3_t = \hat{BV}_t + \frac{(\hat{ROE}_t - r_e)}{(1+r_e)}\cdot\hat{BV}_t + \frac{(\hat{ROE}_{t+1} - r_e)}{(1+r_e)^2}\cdot\hat{BV}_{t+1} + \frac{(\hat{ROE}_{t+2} - r_e)}{(1+r_e)^3}\cdot\hat{BV}_{t+2} + \frac{(\hat{ROE}_{t+2} - r_e)}{(1+r_e)^3\cdot(r_e-g)}\cdot\hat{BV}_{t+2}. \quad (5c)$$

The formulas are in nominal terms. Hence, the *g* (expected growth) denotes growth due to inflation. A reasonable estimate on the average inflation in Norway should be 2.0%; growth because increased future profitability if electricity prices become higher, is held outside the model.

The introduction of future book values also calls for an estimation of dividend payout ratio used in conjunction with the clean surplus relation (CSR). CSR is the fundamental assumption for the Feltham and Ohlson (1995) approach to valuation:

$$BV_{t+1} = BV_t + NI_{t+1} - d_{t+1} \text{ (CSR)}, \tag{6}$$

in which d is the dividend. The dividend payout ratio (k) is assumed constant and is obtained as the average of three previous fiscal years ($\frac{d}{NI}$). This gives:

$$\begin{aligned} BV_{t+1} &= BV_t + NI_{t+1} - d_{t+1} = BV_t + (1-k)\cdot NI_{t+1} = \\ &= \left[1+(1-k)\cdot ROE_{t+1}\right]\cdot BV_t \end{aligned} \tag{7a}$$

$$BV_{t+2} = \left[1+(1-k)\cdot ROE_{t+1}\right]\cdot\left[1+(1-k)\cdot ROE_{t+2}\right]\cdot BV_t \tag{7b}$$

Equations (5)-(7) represent one to three period models for value estimation in the study. This completes the design of the basic benchmark model for the value of electricity generation utilities involved in mergers or acquisitions after deregulation in 1991. The benchmark model is not expected to explain a lot of variations in company values. A comprehensive study performed by Dechow, Hutton and Sloan (1999) on U.S. data 1976-1995 resulted in a R^2 of 0.40 as mean, and a study by Begley, Chamberlain and Li (2006) of the U.S. banking industry 1991-2000 provided a R^2 of 0.28. An examination of U.K. firms 1990-1994 by Stark and Thomas (1998) yielded a R^2 of 0.40. Even so, it will be interesting to see how well the model performs in the important electric utility industry of Norway.

Model 2. As stated, the main purpose of this paper is to test whether the introduction of "real option variables" provides an explanation of the residual variance of transaction values of electric utilities. The underlying assumption is, then, that there are factors beyond earnings that can enhance the explanation of market value. The objective is to include independent variables that can be used as proxies for the level of opportunities (options) for a company involved in a transaction. The following shows an operationalization of two hypotheses derived from real option theory.

The performance of hydroelectric power plants has improved during recent years. In particular, turbine efficiency has significantly improved. Increased knowledge also exists related to expansion of existing plants, including increased inflow to the reservoirs. NWE (Norwegian Water Resources and Energy Directorate – the regulator) has surveyed this potential and estimated it to almost 12 GWh (NWE, 2006). Therefore, it would be appropriate to include proxy variables for the possibility of improving and expanding existing plants of the companies involved in this analysis. Favorable developments in electricity prices and regulatory policies would make such investments profitable.

The average age of existing plants could serve as a proxy for the growth potential concerning improvements and expansions of existing plants. Necessary data are, however, unavailable. Hence, existing capacity serves as a proxy for extension and improvement potential. Existing capacity measured in GWh is obtained from the data. The level of GWh, therefore, serves as a way of measuring the expansion and improvement potential (growth options) not captured by earnings. This discussion suggests the following hypothesis:

Hypothesis 1: Keeping the benchmark value fixed, transaction value increases in production capacity.

Over the last decades, low level of investments in new capacity has been reported. The demand for more electricity generation capacity is widely acknowledged. New large scale hydropower projects are infeasible because of environmental concerns. However, small scale hydroelectric power potential is being considered. NWE has developed a model based on digital maps, hydrological conditions and digital costs of surveying the hydroelectric potential for every municipality (NWE, 2007). The market potential can be estimated as well. A company operating in a region with considerable potential should have a higher option value, compared to companies located in flat areas. The survey of NWE reveals considerable differences in potential between Western and parts of Northern Norway, compared to Central and Eastern Norway.

Growth potential is set as a variable defined as the potential in GWh in the natural surrounding municipalities of the company with the highest cost limitation, as stated in the NWE report. It is difficult to define "natural surrounding" in a simple way. This cannot be the potential in municipalities within some distance, since a number of factors is involved, such as geographical constraints and the number of nearby competitors. Some of the companies in the study also operate in larger regional areas, not just locally. This also complicates defining what can be termed the "natural surroundings" of an enterprise. A possible way is to make an individual assessment of each transaction and include the potential for the nearby municipalities, sometimes, the whole county. But it seems more convenient to use a dummy variable to cover this aspect, denoting whether the company is located in an area with significant potential for new small scale power plants or not. This classification is presented in Appendix 1.

This discussion, then, suggests the following hypothesis:

Hypothesis 2: The transaction value of companies located in areas with more generation development potential will be higher than those located in low development potential localities.

To control the results of the above-mentioned hypotheses for the impact of other factors, the analysis includes the test of some additional explanatory variables. To control a company by owning more than 50% of the shares is often associated with extra value, a control premium. Therefore, an additional test concerning whether the transaction involves the aspect of control is included. The test considers whether there is a higher value when more than 50% of the shares are involved in the transaction.

The value of generation assets is naturally connected to expectations of future electricity prices. Hence, a logical test concerns whether the level of forward prices affects the value. By including the average forward price of the longest contracts traded at Nord, one can test this aspect. A higher level of forward prices would, presumably, be linked to higher transaction values.

There has also been a discussion of whether public owners of generation assets have sold shares in generation companies too cheaply, compared to private sellers. The data make it possible to test whether the transaction value of companies sold by private investors exceeds the value held by public owners.

2. Data, empirical results and analysis

The data of the transactions, in this study, are obtained from the database of Europower AS (a privately owned consulting firm monitoring the industry). As far as we know, no alternative source for information of the relevant transactions exists. The information is obtained during the post deregulation period based on public disclosures. This concerns the date of transaction, object of transaction, transaction value, and the size of generation capacity at the time of the transaction, as well as some supplemental information. The activity of mergers and acquisitions peaked around the year 2000.

The accounting data needed to calculate benchmark values are obtained from the central register of companies, the Brønnøysund Register. This centre is a government body under the Norwegian Ministry of Trade and Industry and consists of several national computerized registers. The database of Europower AS consists of 431 transactions (1991-2006). Many of these transactions concern companies dealing with transmission, distribution and wholesale. Transactions, in which no or very small generation assets are involved, are omitted (below 40 GWh yearly capacity). Of the remaining transactions, some are excluded owing to incomplete data. Some of the plants involved in transactions were not legal entities, making it impossible to obtain relevant accounting information. This leads to a final sample size of 65 transactions, involving 32 different companies (see Appendix 1). Descriptive statistics of these transactions are given in Table 2.

Table 2. Descriptive statistics of the companies and transactions in the analysis

Variable	Number of observations[1]	Average	Median	Q3	Q1
Transaction value[2]	59	2.225.000.000	1.192.000.000	2.987.000.000	459.000.000
k (DIV/NI)	57	0.99	0.64	1.37	0.13
ROE (three years before transaction year)	148	0.03	0.06	0.12	0.01
GWh	65	1211	558	1560	219
Ownership shares traded	61	29.3%	18.6%	42.8%	9.3%
Equity ratio	59	0.56	0.45	0.70	0.34
Price/kWh (NOK)	54	2.37	2.30	2.77	1.77
Price/Book	59	2.72	2.22	2.96	1.42

[1] The number of observations differs from 65 because of some incomplete data. The data of *ROE* concern all available firm years up to three years before the transaction.

[2] The term *transaction value* refers to the compensation given for the shares of the company. If only a part of the shares of the company is involved in a transaction, the term refers to the value *as if* the whole company was involved.

According to Norwegian standards, the figures reveal that the sample consists of enterprises with high average transaction values. This is partly because Hafslund ASA, as a large company (and also a company operating in several industries), is included in 11 of the 65 transactions. Because of low income, and high dividend payout (as in Hafslund ASA), the average payout ratio is as high as one on average. The statistics also show that the industry has relatively high book values of equity ratios and low *ROE* (Bye, Bergh and Kroken, 2001).

The sample should prove sufficiently representative. Even if a criterion that the firm is involved in a transaction, there should be no particular concern relating to possible bias. The sample consists of all kinds of companies, such as the larger ones (Hafslund ASA, Agder Energi AS, Trondheim Energiverk AS), as well as medium-sized and small producers. All parts of the country are represented (14 out of 19 counties).

The data enable the development of two models explaining the transaction value of the electric utilities (*TV*). The first version is to use one to three factor versions of the residual income model:

Model 1.

$$TV_i = \hat{V}^1_{it} = \hat{BV}_{it} + \frac{(\hat{ROE}_{it+1} - r_e)}{(1+r_e)} \cdot \hat{BV}_{it} + \frac{(\hat{ROE}_{it+1} - r_e)}{(1+r_e)\cdot(r_e - g)} \cdot \hat{BV}_{it} \quad (8a)$$

$$TV_i = \hat{V}^2_{it} = \hat{BV}_{it} + \frac{(\hat{ROE}_{it+1} - r_e)}{(1+r_e)} \cdot \hat{BV}_{it} + \frac{(\hat{ROE}_{it+2} - r_e)}{(1+r_e)^2} \cdot \hat{BV}_{it+1} + \frac{(\hat{ROE}_{it+2} - r_e)}{(1+r_e)^2\cdot(r_e - g)} \cdot \hat{BV}_{it+1} \quad (8b)$$

$$TV_i = \hat{V}^3_{it} = \hat{BV}_{it} + \frac{(\hat{ROE}_{it+1} - r_e)}{(1+r_e)} \cdot \hat{BV}_{it} + \frac{(\hat{ROE}_{it+2} - r_e)}{(1+r_e)^2} \cdot \hat{BV}_{it+1} + \frac{(\hat{ROE}_{t+3} - r_e)}{(1+r_e)^3} \cdot \hat{BV}_{it+2} + \cdot + \frac{(\hat{ROE}_{it+3} - r_e)}{(1+r_e)^3\cdot(r_e - g)} \cdot \hat{BV}_{it+2} \quad (8c)$$

This represents the basic benchmark model for estimating the value of electric utility companies based on the residual income model with different timing of the terminal value, and recent accounting information. This approach distinguishes between a one-period, a two-period and a three-period model.

Model 2.

Model 2 introduces additional independent variables derived from real option theory. This is done to test the incremental explanatory power. The regression equations are derived as follows:

$$TV_i = \beta_0 + \beta_1 \hat{V}^1_{it} + \beta_2 GWh_i + \beta_3 PNP_i + \varepsilon_i \quad (9a)$$

$$TV_i = \beta_0 + \beta_1 \hat{V}^2_{it} + \beta_2 GWh_i + \beta_3 PNP_i + \varepsilon_i \quad (9b)$$

$$TV_i = \beta_0 + \beta_1 \hat{V}^3_{it} + \beta_2 GWh_i + \beta_3 PNP_i + \varepsilon_i, \quad (9c)$$

in which GWh denotes the existing capacity of generation in GWh (yearly, middle production), and *PNP* denotes the potential of new plants in the area.

A version of this model with the price/book ratio as dependant variable avoids the problems with heteroschedasticy. By dividing equation (9a) with book value, one derives the following regression equation:

$$\frac{TV}{BV}_i = \beta_0 \cdot BV^{-1} + \beta_1 \frac{\hat{V}^1}{BV}_{it} + \beta_2 \frac{GWh}{BV}_i + \beta_3 \frac{PNP}{BV}_i + \varepsilon_i, \quad (10a)$$

which represents a relative version of model 2, though with no constant term. A version with a constant term becomes:

$$\frac{TV}{BV}_i = \chi_0 + \chi_1 \frac{\hat{V}^1}{BV}_{it} + \chi_2 \frac{GWh}{BV}_i + \chi_3 \frac{PNP}{BV}_i + \varepsilon_i. \quad (10b)$$

3. Empirical results and analysis

The results of the empirical test of the three versions of the residual income benchmark model (model 1) are found in Table 3 (the regressions estimated are: $TV_i = \beta_0 + \beta_1 \cdot \hat{V}^n$, where n refers to 1, 2 or 3 factor version). The Table shows that all three versions of the model, essentially, yield the same results. The model is well established in the data with significant results at conventional levels. The results are consistent with earlier studies on U.S. and U.K. data (Dechow, Hutton and Sloan, 1999; Stark and Thomas, 1998). Because the results of the three versions of the model are similar there will be a focus on the model with the shortest time horizon (V1, equation (7a)) in the following.

Table 3. Results of regression analysis of the three benchmark residual income valuation models

	Number of observations	R^2	Adjusted R^2	F-value	Sig.
Equation (8a)	58	0.427	0.417	42.405	0.000
Equation (8b)	58	0.380	0.369	34.964	0.000
Equation (8c)	58	0.352	0.340	30.932	0.000

Table 4. Regression estimation based on different independent variables

		Variable						
		Constant	$\hat{V}1$	GWh	PNP	R^2	Adj. R^2	DW
Model 1	Unstandardized coefficient	1596678	0.359			0.427	0.417	2.058
	T-value	5.612	6.512					
	Sig.	0.000	0.000					
Model 2	Unstandardized coefficient	242450	0.186	1254	259042	0.848	0.839	1.689
	T-value	0.531	5.010	12.175	0.574			
	Sig.	0.598	0.000	0.000	0.568			
	Unstandardized coefficient	505830		1491		0.766	0.762	1.582
	T-value	2.383		13.666				
	Sig.	0.021		0.000				

The next step is to compare (8a) with (9a) and analyze the correlation between the independent variables. The purpose is to include the variables capturing option values and to test whether this has an incremental explanatory effect. This is done by including the generation capacity (GWh) and the potential in the surrounding area (*PNP*). Defining the surrounding area for a given company is extremely difficult, hence, *PNP* is defined as a dummy variable where the value is 1, if the company operates in an area with substantial potential, and 0 elsewhere. The criterion for having a substantial potential is that the company operates in a county with more than 250 GWh potential (according to NWE). The classification is rendered in Appendix 1. The counties' potential for small scale plants is shown as well.

The results of the regression analysis are presented in Table 4. Several versions are available to examine the data more profoundly, including a version with only GWh as an independent variable. The findings show a significant improvement in explanation of 100 % from (8a) to (9a). The adjusted R squared rises from 0.417 to 0.839 (100% increase)[3].

While both the V1 and GWh variables remain highly significant, this does not apply to the *PNP* variable. To test whether there is a significant empirical difference between model 1 (M1) and model 2 (M2) the following F-value was estimated (*m* is number of linear restrictions (Gujarati, 2003)):

$$F = \frac{(RSS_{model1} - RSS_{model2}) / m}{RSS_{model2} / (n-k)} =$$

$$= \frac{(2.5 \cdot 10^{14} - 6.4 \cdot 10^{13}) / 2}{6.4 \cdot 10^{13} / 55} = 79.897.$$

This value is significant at a 1% level.

Table 5. Correlation matrix (Pearson's correlation) of the independent variables in model 2 (equation (8a))

Variable	$\hat{V}1$	GWh	PNP
$\hat{V}1$	1		
GWh	0.430*	1	
PNP	-0.502*	-0.466*	1

Note: * Correlation is significant at the 0.01 level (2-tailed).

No multicollinearity was detected (*VIF* < 2 for all independent variables). The null hypothesis of homoscedasticity could be rejected at the 5% level when using the Breusch-Pagan/Cook-Weisberg test with regard to model 2. The presence of homoscedasticity diverts the focus to the relative version of the model.

The result of estimating equation (10), where the price/book ratio is the dependent variable, is rendered in Table 6, both with and without a constant term. Also, concerning this model, no multicollinearity was detected (*VIF* < 2, for all independent variables see footnote 4 and Appendix 2b). There is still some heteroscedasticity, but not as much as in model 1. The plot of the standardized residuals against predicted values is shown in Appendix 2a.

[3] The DW indicator becomes low for the two latter versions. Since the data do not represent a pure time series, it is difficult to interpret what the DW actually measures.

Table 6. The regression estimated (equation (10a)) is: $\frac{TV}{BV}_i = \beta_0 \cdot BV^{-1} + \beta_1 \frac{\hat{V}^1}{BV}_{it} + \beta_2 \frac{GWh}{BV}_i + \beta_3 \frac{PNP}{BV}_i + \varepsilon_i$

and a version with traditional constant term (10b)

		Variable						
		Constant	$Book^{-1}$	$\hat{V1}$/Book	GWh/Book	PNP/Book	R^2	Adj. R^2
Eq. 10a	Unstandardized coefficient		-46725	0.218	1231	229523	0.773	0.755
	T-value		-0.928	4.859	7.124	3.182		
	Sig.		0.358	0.000	0.000	0.003		
Eq. 10b	Unstandardized coefficient	1.207		0.154	776	144.731	0.415	0.380
	T-value	3.432		3.404	4.358	2.375		
	Sig.	0.001		0.001	0.000	0.021		

The models are well established in the data, even though the adjusted R squared cannot be compared. The results imply that the price/book ratio is explained by the relationship between conventional valuation and the book value of equity, but also significantly by the relationship between generation capacity and the book value of equity. In addition there is a part that is explained by the inverse of book value of equity for companies located in areas with high potential for growth.

Hence, it is a significant increase in explanation by including the additional variables, compared to conventional valuation of the price/book relationship. In this version of the model also the *PNP*/book variable is significant at a 2% level (1-tailed test). The previous discussion of the variables' connection to real option theory and real option thinking shows, therefore, the relevance of real options in valuation issues.

Table 7. Correlation matrix (Pearson's correlation) of the independent variables (equation (10))

Variable	$\hat{V1}$/book	GWh/book	PNP/book
$\hat{V1}$/book	1		
GWh/book	-0.766*[4]	1	
PNP/book	0.119	0.097	1

Note: * Correlation is significant at the 0.01 level (2-tailed).

4. Additional controls and analysis

The analysis shows that there is a significant increase in value explanation by including the variables in line with real option theory. In total, this yields an incremental explanation of 100% (from adjusted R squared of 0.417 to 0.839, equation (8a) compared to equation (9a)).

There is, of course, a number of additional factors influencing the value and the price/book ratio that have to be considered when assessing the results. Intangible assets, such as human capital and brand equity, are not particularly relevant to this study. Electricity is a homogenous product, and the industry has, to a large extent, fairly equal access to key expertise for managing power generation. However, there are other factors, including the phenomena of mergers and acquisitions, which should be included in this discussion.

The value of companies being acquired tends to exceed market value. This can have many different causes, such as the benefits of control. New owners may possess certain skills or information to make some advantages of the assets, compared to previous owners (synergy) and, hence, be willing to pay a premium (Tirole, 2007). The data for each transaction indicate whether the transaction involves the aspect of control or not, i.e., whether the transaction concerns more than 50% of the shares of the company. An introduction of such a variable in equation (8), (9) or (10) does not show any significance.

Other aspects affecting value are associated with various macroeconomic parameters, such as interest rate, inflation and the general economic situation (Schleifer and Vishny, 1992). These factors are too complicated to be included in the analysis. However, the impact of the general forward price of electricity can be tested. The average forward price of the longest contracts traded at Nord Pool can serve as a proxy for the level of expected long term prices. But this independent variable also fails to contribute in explaining the transaction values.

Yet, another concern relates to the GWh variable and the potential link to the market power issue. Electricity markets are vulnerable to market power (Newbery, 1995; Skaar and Sørgard, 2007). This may, in one way or another, affect the transaction values observed in his study. In the Norwegian context, the state-owned company Statkraft SF controls more than 30% of generation capacity. Only one of the transactions in the sample concerns an acquired company with more the 3 % of total generation (Agder Energi AS with 9.8 GWh generation of a total 121 GWh, i.e., approximately 8%). Hence, this aspect should not have any particular impact on the results.

[4] The strong negative correlation is caused by one extreme observation (see Appendix 2b). If that observation is ignored the correlation becomes 0.017 (which is insignificant).

The age of the plants could be a possible variable that affects value. One should, though, bear in mind that hydropower plant assets have some different characteristics, compared to other generation assets. When hydropower plants are constructed, major parts of the assets, as reservoirs and tunnels, are close to infinite living. The issue of age will, hence, not have the same impact, as would be the case for thermal power plants or wind mill parks.

Finally, the results are tested for whether a seller being public affects transaction value. There is, however, no significant impact of this variable.

Conclusions, implications and limitations

It is impossible to comment on all potential factors affecting the transaction values studied in this paper. Nevertheless, the models presented support the theory that independent variables based on real option reasoning seem to be omitted variables in model 1. However, the above discussion offers other possible explanations. It is hard to explain and understand values of complex companies in the generation industry.

Regarding the *PNP* variable, there should also be some additional remarks. As shown in Appendix 1, there are only three companies classified as located in flat areas. One of these, Hafslund ASA, is involved in eight of the transactions. One should bear in mind that this company is characterized by possessing river plants, and not reservoirs. River plants do not provide the kind of flexibility that is associated with reservoirs; that is, the ability to generate relatively more in peak price periods (in winter). The GWh capacity of a river plant is, hence, less valuable than reservoir plants. Therefore, it is possible that the *PNP* variable is capturing this aspect rather than location.

The sample of this study shows that the industry is characterized by high book values and rather low equity profitability. Therefore, the three different versions of the RI model do not vary much, indeed. In the post-deregulation period, a restructuring of ownership occurred in the industry with a peak of transactions in the years 1999-2001. The activity, actually, has decreased considerably during recent years. This may be linked to the increase in electricity prices in the years 2002-2010. The uncertainty caused by several aspects, such as rising demand without corresponding increase in supply, CO_2 allowances, the introduction of green certificates and the issue of the home fall institute make owners of hydroelectric power hesitant to sell. This seems easy to understand, of course, bearing in mind the highly volatile prices.

The residual income valuation model of Feltham and Ohlson (1995) explains approximately 40% of the variation in the company values in the generation industry. The results show that secondary data of option components do contribute in explaining transaction values of electric utilities involved in mergers or acquisitions over and above the explanatory power provided by the residual income valuation framework. The incremental explanation is substantial, as the adjusted R squared rises from 0.417 to 0.839 moving from model 1 to model 2.

Despite shortcomings and limitations, the findings, based on a unique data set, provide support for the real option approach for understanding business value in this industry. The econometric discussion leads to a focus on the relative versions of the model in which the findings are most convincing. The analysis shows how the price/book ratio can be explained beyond what is captured by conventional valuation techniques. These findings may be used to argue that option aspects do affect the value beyond that captured by traditional valuation based on earnings.

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Appendix 1

List of companies involved in the transactions included in the analysis (year of transaction in brackets). Some have been involved in several transactions during the same year.

The classification of being in an area with high (1) or low (0) potential regarding new hydroelectric power plants is also indicated.

Company	County	County potential (GWh)
A/S Oppdal Everk (1996,2004) (1)	Sør-Trøndelag	562
Agder Energi AS (2001) (1)	Vest-Agder	707
Arendals Fossekompani ASA (1996,2003) (1)	Øst-Agder	476
EAB Produksjon AS (Energiselskapet Asker og Bærum) (1999) (0)	Akershus	0
Eastern Norge Svartisen AS (2003) (1)	Nordland	3862
Elkem ASA (2005) (1)		
Finnmark energiverk AS (1993) (1)	Finnmark	542
Firdakraft AS (2000) (1)	Sogn og Fjordane	5285
Hafslund ASA (1996,1997,1998,1999,2000,2001,2002,2003) (0)		
Hedmark Energi AS (2001) (1)	Hedmark	293
Hellefoss Kraft AS (2002) (1)	Buskerud	658
Herlandsfoss Kraftverk AS (2001) (1)	Hordaland	3993
Istad Kraft AS (2000,2001) (1)	Møre og Romsdal	2696
Narvik Energi AS (1999,2002) (1)	Nordland	3862
NEAS (Nordmøre Energiverk) (2001) (1)	Møre og Romsdal	2696
Nordkraft AS (2000) (1)	Nordland	3892
Nyset-Steggje kraft AS (2000) (1)	Sogn og Fjordane	5285
Oppland Energi AS (2001) (1)	Oppland	939
Oppland Energiverk AS (2001) (1)	Oppland	939
Rødøy-Lurøy Kraftverk AS (2001) (1)	Nordland	3862
Salten Kraftsamband AS (2004) (1)	Nordland	3862
Sogn og Fjordane Energi AS (2001) (1)	Sogn og Fjordane	5285
Sognekraft AS (1998,1999) (1)	Sogn og Fjordane	5285
Sunnfjord Energi AS (1997,1999,2000) (1)	Sogn og Fjordane	5285
Sunnhordland Kraftlag AS (2000) (1)	Hordaland	3693
Tafjord Kraft AS (1999,2001) (1)	Møre og Romsdal	2696
Telekraft AS (1998) (1)	Telemark	774
Trondheim Energiverk AS (2002) (1)	Sør-Trøndelag	562
Tussa Kraft AS (2000,2001) (1)	Møre og Romsdal	2696
Vittingfoss Kraftstasjon AS (2004) (0)	Vestfold	74
VOKKS AS (2001) (1)	Oppland	939
Voss og Omland Energiverk AS (2002) (1)	Hordaland	3693
Østerdalen Kraftproduksjon AS (2003) (1)	Hedmark	293

Appendix 2A

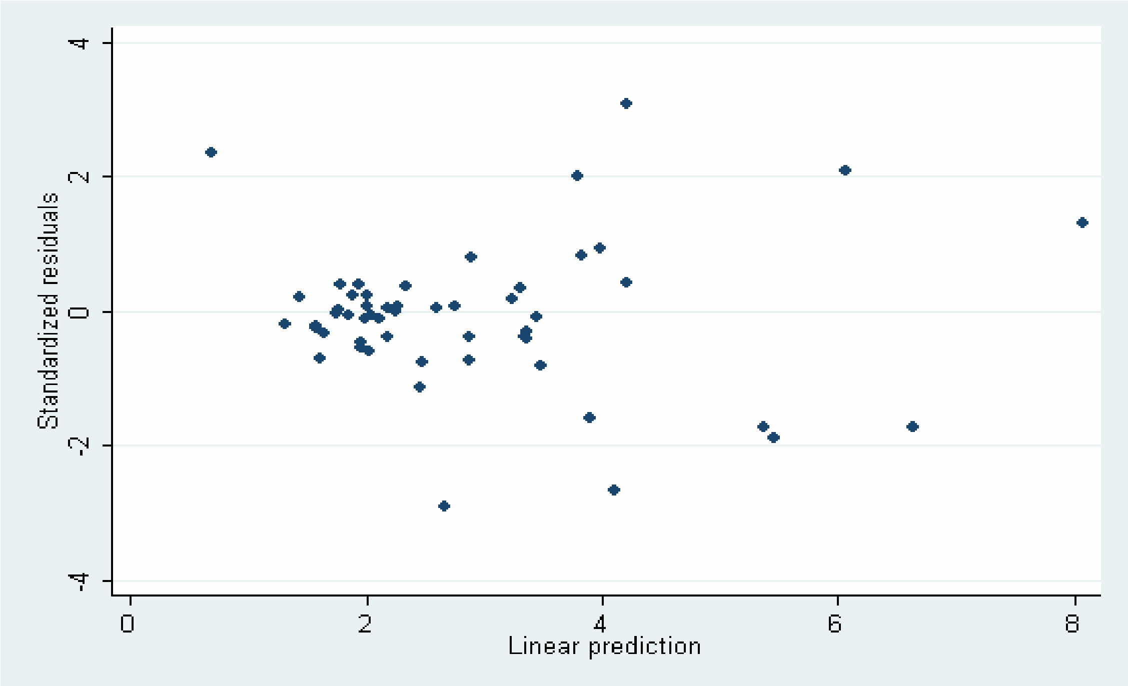

Fig. 2. Plot of standardized residuals versus predicted value (relative version, model 2, eq. (10a))

Appendix 2B

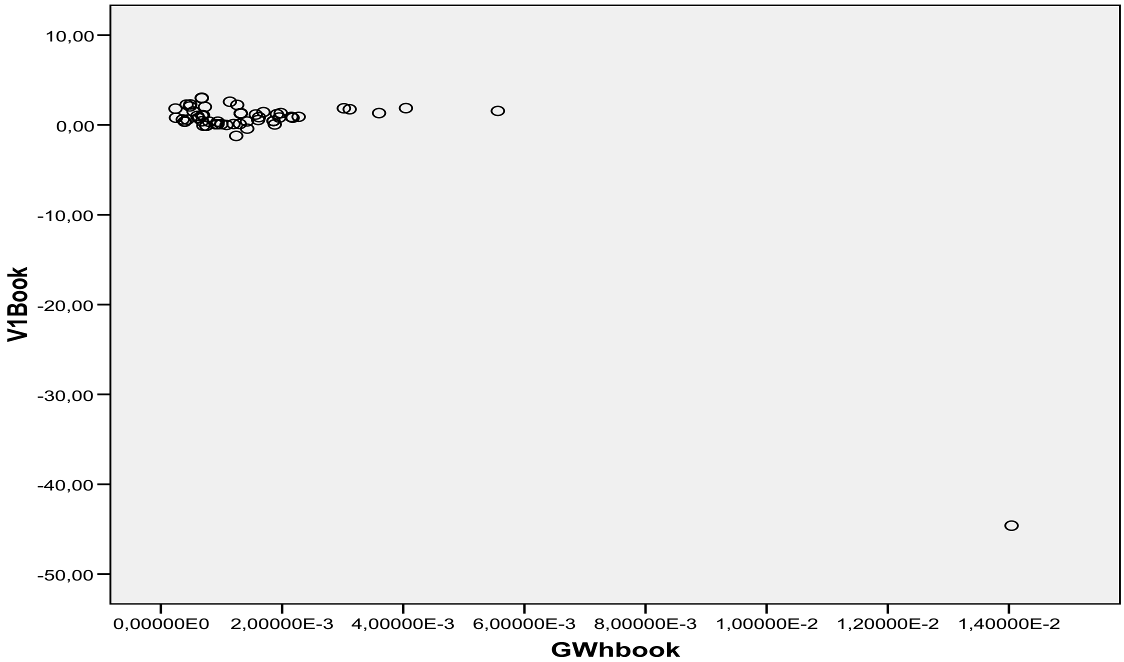

Fig. 3. Scatter plot of the GWh/Book variable with the V1/book variable in eq. (10a) and (10b)