Real Options in the Electricity Sector. The case of Endesa's Expansion in Latin America

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ABSTRACT: The goal of this paper is to increase current empirical evidence on the relevance of real options for explaining both firm investment decisions and equity pricing. We study an actual investment case in the power industry, Endesa's expansion strategy in Latin America. We identify two important valuation dates: 30 July and 30 October 1997. These dates mark, respectively, the initial agreement between Endesa and insider shareholders in Enersis, and subsequent restructuring. Despite the initial negative NPV on the investment, the estimated value of one of the growth options justifies its acceptance under reasonable conditions. Additionally, estimated values attributable to this growth option provide new insights into the influence of real options on investor valuations.

Key words: Real options; Monte Carlo simulation; Capital budgeting in electricity companies; Firm valuation.

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1. INTRODUCTION

Real option valuation emerged from the proposal by Myers (1977) as a solution to certain restrictions inherent in the discounted cash flow (DCF) model. Real option valuation considers active management of corporate investments and, therefore, the value of their flexibility. In addition, this model takes into account non-monetary outcomes from previous resource allocations, which become sources of new opportunities for future growth. Real option valuation is grounded on the analogy between decision rights derived from business investment and put and call financial options. This analogy allows a broad set of powerful and widely tested analytical models and numerical valuation techniques to be imported from Option Pricing Theory.

Theoretical research in this field has far outpaced empirical research for mainly methodological reasons. Unlike financial options, for real options there is usually a lack of market value references with which to compare model valuations or even contrast their impact as a source of corporate value. Exceptions are limited to certain resource allocations, the nature of which allows easy identification of the market value accounted for by its implicit real options. Such examples include offshore oil leases in Paddock, Siegel and Smith (1988) or building land in Quigg (1993).

Faced with this hurdle, certain studies posit indirect estimation, involving approximation of the market value attributable to a firm's real options through the difference between its total market value and estimated value of its assets-in-place. Should the real option valuation hypothesis prove certain, the part of the market value not attributable to assets-in-place should reflect the changes in the variables on which real options depend, as would the value of a financial option. Using this approach, Berger, Ofek and Swary (1996), and Andrés, Azofra, and Fuente (2006) find evidence to support the valuation of firm options to abandon and to invest respectively. Alternatively, increasing managerial interest in real option valuation may be seen as a further indication of the importance of real options. Recent studies, such as those by Graham and Harvey (2001) and Brounen, Jong and Koedijk (2004), reflect the gradual incorporation of the real options approach as a capital budgeting technique.

However, the most widely used approach in empirical research is case studies, which enable a detailed analysis of the process of investment value creation and the variables on which it depends. Most case studies have dealt with natural resources (Kulatilaka, 1993; Laughton and Jacoby, 1991; Smit, 1997; Moel and Tufano, 2000; Rocha, Moreira, Carvalho and Reis, 2006), due mainly to the greater availability of historical data series (Sick, 1989). In recent years, evidence has spread to other areas such as biotechnology (Miccalizzi; 1999, Amram and Kulatilaka, 1999; Kellogg and Charnes, 2000; Stark, 2001; León and Piñeiro, 2004; Rubio and Lamothe, 2006) or internet (Sáenz-Diez, 2004), which are characterized by high business and technical uncertainty. Other studies include the valuation of taxi licences by Albertí, León and Llobet (2003); the remodelling of a naval port by Juan, Olmos, Pérez and Casasús (2002); a real estate investment by Rocha, Salles, Augusto, Sandinha and Teixeira (2007); or a foreign investment in the car components industry by Azofra, Fuente and Fortuna (2004).

We aim to broaden the scope of case study research evidence by analysing an investment in the electrical energy sector. The specific case is Endesa's entry into the capital of the Chilean electricity group Enersis through a strategic agreement with its insider shareholders. This project is representative of "strategic" or "necessary" investments, the acceptance of which is not justified in terms of direct cash flow estimations but which are defended by managers due to their strategic potential.

Our study focuses on the nature of the agreement and its sources of value as a means to evaluate the significance of real options. Our departure point is the real options' main hypothesis (Myers, 1977; Kester, 1984), which posits that the value of a firm's equity, E_0, may be broken down into the sum of the assets-in-place value attributable to shareholders, E_0^{AiP}, and the value of the growth options' portfolio, E_0^{GO}:

$$E_0 = E_0^{AiP} + E_0^{GO}$$

Our analysis of the agreement signed between Endesa and the board of Enersis reveals the embedded real options to be those linked to future expansion in Latin America and specifically the option to expand into the Brazilian market. At the time of the agreement, the electricity sector in Brazil was immersed in a process of privatisation, with bidding expected for practically the whole of the distribution network within five years. Endesa's participation in Enersis provided a gateway to the Brazilian market assimilated to a *pseudo-American* call option. We estimate the value of this option by using a model based on Longstaff and Schwartz (2001), which we adapt to the nature of the investment analysed.

The information required for the case study was gathered from financial publications at the time of the investment, analysts' forecasts, public documents presented to the market by Endesa and finally, data collected from in-depth interviews with those managers heading the expansion process in Latin America. We estimated the investment value on two consecutive dates, 30 July and 30 October 1997, coinciding, respectively, with the initial agreement on Endesa's entry into Enersis and the subsequent renegotiation.

The findings to emerge from the case study provide evidence to support the significance of real options in explaining the decision to invest and Endesa's market values. Firstly, the value of the growth option in Brazil endorses the logic of Endesa's investment agreement for a wide and acceptable range of scenarios. Secondly, losing this growth option in the subsequent renegotiation of the original agreement is reflected in the fall of Endesa's stock prices, thus evidencing the posited impact.

The remainder of the work is structured as follows. The second section outlines the main features of the investment analysed. The third section provides an estimation of the value accounted for by the assets-in-place. The following section is devoted to describing the main growth option embedded in the venture and to modelling its sources of value. Section four presents the estimation of the main parameters needed for the valuation and offers the main results in the growth option valuation. Section five discusses the relevance of the growth option value, both in the firm's decision to invest as well as in its stock prices in the light of the evidence analysed. The paper closes with a summary of the main conclusions.

2. ENDESA'S INVESTMENT STRATEGY IN LATIN AMERICA

The case to be studied focuses on Endesa's entry into the capital of the Chilean electricity group Enersis in mid 1997. In the light of press information and remarks made by those heading the operation, the aim of Endesa's investment was to gain a foothold as a global operator in the Latin American market. It was a key date due to impending privatisation in the area as a whole and in Brazil in particular, given the size of potential demand in this country. Enersis was the leading private electricity conglomerate in Latin America, controlling production in Chile, –through Endesa Chile– and distribution –through Chilectra–, thanks to its network of affiliated companies and subsidiaries. It also held major interests in electric companies in Argentina, Peru and Brazil.

The various stages which Endesa's entry in the Chilean group underwent and the impact on the investment's sources of value advocate differentiating between two pivotal dates in the valuation: the first when the initial terms of the agreement were drawn up on 30 July 1997, and the second, 30 October, when Endesa forfeited control over the Chilean group.

On 30 July 1997, Endesa announced that it had signed an investment agreement with a group of Enersis insider shareholders. This group comprised a small number of executives who were founders of five Chilean investment companies known as Chispas,[1] which held 29.04% of Enersis' capital. Although these insiders owned a mere 0.06% of Chispas' capital, they held "preferential" shares –the so-called series B shares[2]– granting them the majority of decision rights. The insider group also had the support of the Pension Fund Administrators (AFPs), who together formed Enersis' principal shareholder with 32% of the capital, but who were not involved in management decisions through legal imperative. As a result, the insider group controlled the majority of the Enersis board as well as the boards of the companies and subsidiaries through which its activities were organised.

The initial agreement between Endesa and the insider group enabled the Spanish firm to acquire a significant share of Enersis' capital and gain control over future investments abroad, in exchange for payment of 1,500 million dollars. One of the most striking features of the alliance was how Endesa would reach a majority of capital in Chispas, which involved launching takeover bids for series A shares and drawing up share deal and management contracts with series B shareholders. The agreement included the setting up of Endesis, 55% of which would be controlled by the Spanish company and the remaining 45% by the Chilean. Endesis' mission was to channel Endesa and Enersis investments throughout South-America. Moreover, Endesa reserved the right to veto any future investments which Enersis might consider undertaking independently.

The unequal payment made to holders of the two kinds of Chispas shares –over 1,000% in favour of the B series after applying percentage ownership differences– initially caused great reluctance towards the agreement. However, gradual awareness of the remaining clauses sparked the greatest mistrust amongst Enersis' shareholders, including the AFP's.[3] At the end of October, three months after the initial agreement, the pressure

[1] Compañía de Inversiones Chispa Uno S.A., Compañía de Inversiones Chispa Dos S.A., Compañía. de Inversiones Los Almendros S.A., Compañía de Inversiones Luz y Fuerza S.A. and Compañía de Inversiones Luz S.A.

[2] Together with series B shares, Chispas equity comprised series A shares held mainly by employees or former employees of Enersis, representing 99.94% of the total and who held the right to a greater share of the dividends but to a smaller stake in control.

[3] The AFPs' loss of trust put paid to the power exerted by Chispas, over which Endesa sought to gain control, as they had traditionally enjoyed the support of two representatives of the AFPs on the Enersis board.

exerted by these shareholders led to a thorough review of the agreements signed with Enersis' insiders. Renewed talks were directly conducted between representatives of Endesa and the AFPs, reflecting the difficulty the Spanish electric company faced in its efforts to gain control over the group with the payments it had made.

As a result of the renegotiation, a new means of undertaking joint investments was established, which involved an individual study of each opportunity and the setting up of companies with an equal split in each case.[4] This way to invest jointly differed enormously from what the Spanish firm had initially envisaged. As a consequence, Endesa lost its decision rights over future Enersis investments, including the much coveted expansion option into the Brazilian electricity market.

3. ASSETS-IN-PLACE VALUATION

Breaking down sources of value into assets-in-place and real options allows us to calculate the value of the former using the discounted net income model (Kester, 1984), which involves identifying non-discretionary investments with the economic maintenance of current assets.[5] Assuming that net income increases at a constant rate *g*, the value of equity attributable to assets-in-place is given by the expression:

$$E_0^{AiP} = \frac{NI_1}{k-g} \qquad (1)$$

where NI_1 represents the net income in the following period and *k,* the risk-adjusted discount rate.

When estimating the parameters required by the valuation of Enersis' assets-in-place at the two key dates –30 July and 30 October 1997– we use the expected earning per share to emerge from the mean consensus forecast made by analysts for the following fiscal year. This information is taken from the I/B/E/S historical database provided by *Datastream*, two months before and ten months after each valuation date.[6]

Risk-adjusted discount rate, *k*, is estimated before and after renegotiation by

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[4] Only when one of the parties renounces its 50% may the other increase its participation or invite third parties.

[5] For further details on the link between net income and cash flow and its implications for valuation, see Fernández (2006).

[6] Our study reveals that an estimation of the net profit for periods close to the valuation date fails to evidence any significant changes.

using the Capital Asset Pricing Model (CAPM). Risk free rate is obtained from the arithmetic average of 10-year US bonds returns (6.22% and 6.03%, respectively), while beta coefficients are obtained from the monthly correlation of Enersis' returns and the *S&P Global 1,200* Index over the five preceding years (0.587, and 0.65 at each point). Finally, the annual inflation rate for the American dollar is estimated to be 3% in both cases, and the risk premium to be 4.23% as calculated in Fama and French (2002).

The estimated value of Enersis equity attributable to its assets-in-place before and after renegotiation is shown in Table 1. The value of Endesa's share is obtained by merely considering its 29.04% stake. The difference in value in the Chilean group's assets-in-place at the two dates scarcely amounts to one million dollars, due to the increase in its overseas businesses in mid September. At that moment, Enersis together with Endesa, was granted control over two companies in Colombia arising from the splitting of the Colombian national Energía Eléctrica de Bogotá (EEB) into two other companies: Emgesa (producer) and Codensa (distributor).

[Insert Table 1]

Taking into account the number of Enersis' stocks (6,800,000,000 at both moments) gives a share value of 0.455 dollars and 0.456 dollars –190.59 and 189.12 Chilean pesos– respectively. In both cases, the value equity attributable to its assets-in-place is lower than its market price of 255.31 and 230.8 Chilean pesos, providing clear evidence of the value for growth opportunities which investors attach to the Chilean holding company.

4. CHARACTERISING THE GROWTH OPTION IN BRAZIL

Aside from acquiring Enersis' assets-in-place, Endesa's investment also provided the opportunity to expand into the Brazilian electrical power distribution market.[7] More specifically, the agreement enhanced its early opportunity to expand into Brazil, a possibility Endesa already held on its own due its being a global operator in the power sector. Hence, a correct valuation of Endesa's strategy involves calculating the incremental value of the growth option in Brazil based on the alliance with Enersis in comparison to the value of the option Endesa held by itself.

[7] Although not the only option acquired by Endesa, it is the most important. Focusing the analysis on this one option in no way undermines the main goal of our research but serves to significantly simplify the presentation of the results.

In July 1997, the call for tenders from distributors was imminent, the Brazilian government having declared its intention to dispose of its participation –around 93.5% of the total[8]– in no more than five years. Since neither the precise moment nor the exact amount of each bid were known at the time of the investment, for the purpose of valuation we consider a uniform distribution of the total to be put out to tender in each of the semesters of the following five years.

The investment opportunity in Brazil may therefore be likened to a *pseudo-American* style call option –also known as *Bermuda*– with a six-monthly exercise. Exercising the option was conditioned to a successful bid in the corresponding public call, and provides access to electrical distribution networks over a given leased area. In order to verify the robustness of the valuation, the conditional exercise is modelled in two alternative ways; firstly, by overpricing the reference price expected in the tender, with the subsequent increase in the exercise price and the possibilities of a successful bid,[9] and secondly by weighting the exercise value by its estimated successful bid probabilities.[10] The commonplace practice of creating consortiums to compete in public tenders reduces the number of potential competitors, we assuming there to be two or three consortiums with a similar chance of success in each round of bidding.

The cash flows to emerge from a successful bid depend on the difference between the revenue and the cost of acquiring the energy distributed, in other words, the total gross margin relating to the activity, less the amount corresponding to other payments involved therein:

$$CF_t = (GM_t - Cost_t)(1 - \tau)$$

GM_t being the total gross margin derived from the distributors' main activity; $Cost_t$ other payments; and τ the tax rate.

The total gross margin is based on the margin per unit of energy distributed, M_t, and the proportion, s, of the demand for electricity in Brazil, D_t, to be satisfied through the assets allocated in the tender:

$$GM_t = M_t \cdot s \cdot D_t$$

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[8] This is the participation to emerge after tenders from the distributors Escelsa, Light and Cerj. The latter had been awarded to the Endesa-Enersis alliance.

[9] Clearly, the greater the premium offered, the lower the value of the investment opportunity.

[10] Smit (1997) posits the same approach for the value of offshore oil concessions, where exercising the option to exploit the reserve is conditioned by successful exploration.

Other payments covers any item reducing the gross margin and includes: i) other expenses linked to the main activity –staff costs, material expenses, fuel,...–; ii) financial results; and finally, iii) costs arising from maintaining investment infrastructure. We assume these cash flow components to represent a proportional part, P_1, P_2 and P_3 respectively, of the distribution margin:

$$Cost_t = (P_1 + P_2 + P_3) \cdot GM_t$$

Finally, business taxation is estimated as a zero-truncated function, tax being levied if profit is above zero or yielding the right to loss compensation on subsequent years should this not be the case.

4.1 Sources of uncertainty involved in distribution

Analysis of the energy distribution market in Brazil reveals two main sources of risk: the unit margin and the demand for electricity. As the cash flows underlying the exercise of the growth option depend on the evolution of these variables, valuing the investment requires modelling their future stochastic behaviour pattern.

A) The distribution unit margin

To identify the stochastic process of the unit margin we use the variable defined by the Brazilian authorities in their privatisation programme: the distribution indicative margin. We characterise future evolution based on historical series of variations in the Gross Domestic Product for the Electricity, Gas and Water sector, which show that this variable follows a lognormal diffusion process. We also consider the possibility that the authorities may occasionally alter this margin, giving rise to anomalous variations, through the addition of a Poisson jump into the process.

The consequent stochastic process proposed for the distribution margin comprises two parts: i) a continuous variation, represented by a geometric Brownian process, and ii) discrete variations expressed through a jump process; as shown in the following stochastic differential equation:

$$dM_t = (\alpha_M - \lambda_M k_M) M_t dt + \sigma_M M_t dz_M + (\pi_M - 1) M_t dq_M$$

where α_M and σ_M stand for, respectively, the expected drift and volatility of the continuous motion; (π_M -1) is the random variable measuring the size of the proportional jump in the distribution margin; λ_M the mean frequency of the discrete jumps per unit of time; k_M the mean size of the jump; and dz_M and dq_M represent the Wiener stochastic process and the jump process, which we assume to be independent and characterised by their standard expressions:

$$dz_M = \xi \cdot \sqrt{dt}, \quad \xi \to N(0,1)$$

$$dq_M = \begin{cases} 0 & \text{prob} = 1 - \lambda_M \cdot dt \\ 1 & \text{prob} = \lambda_M \cdot dt \end{cases}, \quad q_M \to Poisson[\lambda_M]$$

Regarding the possibility that discontinuities may occur in the evolution of the margin we assume the direction of the jump to be unknown a priori and the mean impact on the drift of the variable to be zero (Merton, 1976). Likewise, we suppose the size of each jump to be independent and that $log(\pi_M)$ follows a normal distribution with mean $\mu_{\pi,M}$ and deviation $\sigma_{\pi,M}$. Based on these considerations, the mean size of the jump is expressed as:

$$k_M = E[\pi_M - 1] = \exp\left(\mu_{\pi,M} + \frac{\sigma^2_{\pi,M}}{2}\right) - 1$$

where $\mu_{\pi,M}$ should take the value $-\sigma^2_{\pi,M}/2$ for the mean size of the jump to be zero, in other words, $k_M = 0$.

B) Demand for electrical energy in Brazil

We characterise future energy consumption in Brazil based on historical series of annual variations. This analysis leads us to presume that the endogenous variable follows a geometric Brownian process. However, one noticeable feature in the overall variation in demand is an unusual jump caused by Brazil being highly dependent on hydraulic energy coupled with its poor links to other grids from which it may import energy. These factors jeopardise the country's ability to meet demand during dry spells.[11]

Taking this into consideration, we assume the best stochastic process describing the evolution of power consumption in Brazil to include *downward* discontinuities distributed following a Poisson process, its infinitesimal variation corresponding to the following equation:

$$dD_t = (\alpha_D - \lambda_D k_D) D_t dt + \sigma_D D_t dz_D + (\pi_D - 1) D_t dq_D$$

where the parameters are defined as in the previous case. The only difference lies in the size and direction of the jump, which in the case of demand is assumed to be known for

[11] Implementing programmes to ration electrical energy consumption may lead in these cases to a reduction in distribution company cash flows, as occurred between 2000 and 2001.

certain.

4.2 Modelling the value of the underlying investment

To determine the value of the underlying asset of the growth option in Brazil, we assume the usual complete markets hypothesis, allowing us to estimate "risk neutral" evolution of the sources of risk and discount the adjusted cash flows to the risk free interest rate. When adjusting the stochastic evolution of the state variables for systematic risk, we assume the risk from the discontinuous jump of each state variable to be diversifiable (Merton, 1976). Based on this consideration, risk neutral evolution is determined by the modified continuous trend, r-δ, which replaces the initial α drift for each source of uncertainty:

$$dM_t = (r - \delta_M - \lambda_M k_M) M_t dt + \sigma_M M_t dz_M^* + (\pi_M - 1) M_t dq_M$$

$$dS_t = (r - \delta_S - \lambda_S k_S) S_t dt + \sigma_S S_t dz_S^* + (\pi_S - 1) S_t dq_S$$

and $dz_S^* dz_M^* = \rho dt$

where δ represents the *convenience yield*[12] and ρ the correlation coefficient between unexpected changes in electrical power consumption and the distribution margin.

The value of the cash flow underlying the exercise of the option at a given point *t*, is obtained from the convolution of the cash flows which are expected to be generated from that moment until expiry:

$$E_t^{GO}(D_t, M_t) = \int_t^T CF_w e^{-rw} dw$$

r being the risk free rate. The life span of the underlying investment is assumed to be infinite and is divided into an initial period of ten years, $T = 10$, at the end of which the investment is assumed to generate a perpetual cash flow equal to the last estimated one.

Applying Itô's Lemma yields the dynamic of the value of the investment in Brazilian energy distribution expressed in terms of the previous state variables:

$$dE_t^{GO} = \frac{\partial V}{\partial t} dt + \frac{\partial V}{\partial D_t} dD_t + \frac{\partial^2 V}{\partial (D_t)^2} (dD_t)^2 + \frac{\partial V}{\partial M_t} dM_t + \frac{\partial^2 V}{\partial (M_t)^2} (dM_t)^2 + \frac{\partial V}{\partial D_t M_t} dD_t dM_t$$

[12] This adjustment is equivalent to deducting from the continuous drift the equivalent risk premium from financial assets (Trigeorgis, 1996:102).

The difficulty generally inherent in deriving a manageable expression for the above stochastic differential equation advocates the use of numerical procedures for resolving it. Following recent research (Schwartz and Moon, 2001 and 2002; León and Piñeiro, 2004; Schwartz, 2004; Miltersen and Schwartz, 2004; Rubio and Lamothe, 2006; and Abadie and Chamorro, 2006), the procedure we use to value the option to invest in Brazil merges Monte Carlo simulation, dynamic programming and statistical regression. The model applied is an adaptation of the proposal by Longstaff and Schwartz (2001) to value corporate investment and its real options. Discretisation of the continuous process of the endogenous variables involved in the use of simulation is performed using the following expressions for the distribution margin and demand respectively:

$$M_t = M_0 \exp\left[\left(r - \delta_M - 0.5\sigma_M^2\right)\Delta t + \sigma_M z_0 \sqrt{\Delta t} + \sum_{i=1}^{q}\left(\sigma_{\pi,M} z_i - \sigma_{\pi,M}^2 / 2\right)\right]$$

$$D_t = D_0 \, exp\left[\left(r - \delta_D - 0.5\sigma_D^2\right)\Delta t + \sigma_D z_0 \sqrt{\Delta t}\right]\prod_{i=1}^{q} \pi_{D,i}$$

5. VALUING THE OPTION TO EXPAND IN BRAZIL

5.1 Input parameter estimation

The cost of exercising the option to expand in Brazil is estimated using the data available from previous tenders involving three other companies. Taking into account the amount of energy distributed by each company, as shown in Table 2, the mean outlay per megawatt amounts to 186.75 dollars. To include the risk of a successful bid in the public tender, we use, alternatively, i) overpricing through premium payments ranging between 10 and 50% over the public tender reference price; and ii) weighting the strike value of the opportunity by the estimated likelihood of a successful bid, with values ranging between 33 and 66%.

[Insert Table 2]

Using the information provided by the Instituto Brasileiro de Geografía y Estadística (Brazilian Institute for Geography and Statistics), the tax levied, τ, is estimated at 30%. Taking an average market share allocation at each round of bidding of 9.35% and an average minority stake reserved to local shareholders of 20%, the market share corresponding to the alliance in the case of exercise, s, is estimated at 7.5%.

A look at the balance sheets of various similar Brazilian distributors[13] operating around the same period analysed provides an approximation of the percentages corresponding to other payments to be deducted from the gross margin. Specifically, the percentage attributable to other exploitation costs, P_1, comes to 50%, for financial results, P_2, to 5%, and costs related to investments in maintenance of assets, P_3, to 20%.

At the initial agreement date, the Brazilian authorities' forecast for the distribution indicative margin amounts to 27 dollars per megawatt, it being assumed to recover in line with the growth rate of the country's electrical energy consumption. Further, and in accordance with forecasts by the Ministerio de Minas y Energía de Brasil (Brazilian Ministry for Mines and Energy), we assume it to level out at around 47 dollars, which would act as an absorbing barrier. The variation of the logarithm of the annual GDP series for the Electricity, Gas and Water sector between 1953 and 1996, expressed in 1996 constant values, reveals a lack of sufficient empirical data to reject the null normality hypothesis based on the Kolmogrov-Smirnof test with a *p-value* of 0.568. Statistics for said variation show an annual expected drift of 8.05% and a standard deviation of 4.57%, whilst as of 1997 the expected annual inflation rate in dollars for the gross margin is estimated at 3%.

The beta coefficient of the above GDP indicator, estimated from the link between its historical annual variations and those of the *S&P*-500 portfolio for the 1973-1997 period is 0.14. In line with the CAPM and the 6.22% and 4.23% estimations in the risk free rate and market premium, this beta coefficient would yield a return in dollars of 7.03%. Finally, parameters linked to the discontinuous variation in the distribution margin are analysed using alternative volatilities for jump sizes between 25 and 50% with an average of one jump each ten years ($\lambda_M = 0.1$).

As a starting point for electrical energy consumption in Brazil we took the 277,685 gigawatts recorded at the beginning of 1997. The historical series of annual values for 1952-2003 allows us to characterise its stochastic behaviour pattern.[14] These data show that there is insufficient evidence to reject null normality hypothesis according to the Kolmogorov-Smirnov test (*p-value* = 0.323). Expected annual drift and

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[13] Specifically we consulted the balance sheets and statements of Coelce, Cerj and Coelba, whose size may provide a reference for the alliance's investment opportunity in Brazil.

[14] Although valuation was performed on 30 July 1997, we used historical data series covering 1952-2003 so as to include the effect of a severe drought between 1999 and 2000 in the analysis of the stochastic behaviour of the state variable.

standard deviation to emerge from the variation of the logarithmic transformation of the original series are 7.60% and 4.34% respectively. The systematic risk inherent in electrical energy consumption is reflected in the 0.1092 beta coefficient, the capital cost resulting from the CAPM equation being 6.90%.

The abnormal variation linked to the risk of a reduction in the ability to meet demand during a prolonged drought (π_D - 1) is assumed at 15%. Such a drought is deemed likely to occur each fifty years (λ_D = 0.02). As a result, the mean annual variation rate caused by discrete variations is 0.3%. Consequently, the expected drift for continuous movement, obtained by deducting from the total variation of the variable the part corresponding to the discrete variation is 7.9%. Finally, correlation analysis between non-anticipated changes in the variation of power consumption and the distribution margin evidences a 90% correlation at a 95% significance level ($\rho = 90\%$).

Valuation comprises 10 annual periods, at the end of which the investment is assumed to generate a constant cash flow equal to that obtained during the last period. Exercising the investment opportunity in Brazil is evaluated each semester during the first five years. The number of simulated paths for each state variable is 800,000: 400,000 (200,000 direct approximations + 200,000 antithetical) for estimating the optimal exercise frontier and another 400,000 (200,000 + 200,000) for estimating the present value of the option.[15] [16]

5.2 Valuation results

Table 3 shows our valuation results for the option to expand in Brazil. The first three columns in Table 3 reveal the value of the growth option corresponding to the Endesa-Enersis alliance taking into account the two alternatives considered to include competitor risk during bidding. The remaining columns show the marginal value of the option attributable to the alliance, namely, the difference between the value of the opportunity to expand into Brazil for the Endesa-Enersis alliance and the value of the same opportunity for Endesa on its own.[17]

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[15] Using two sets of different values may be justified by the upward bias involved in estimating the frontier and the value of the right based on the same sample of simulated values (Broadie and Glasserman, 1997).

[16] The time required to execute the valuation procedure is 15 minutes on a computer carrying an Intel Pentium M 740 processor at 1.73 GHz and 1Gb memory.

[17] Modelling and estimating the parameters of the growth option for Endesa on its own concurs with those

[Insert Table 3]

As expected, the valuation results in Table 3 show a negative relation between the value of the investment opportunity in Brazil and the premium paid: the higher the price of exercise determined by the premium, *ceteris paribus*, the lower the present value of the growth option. Likewise, option values in panel B increase with the likelihood of a successful bid.

Our valuation results also show that an increase in regulatory uncertainty reduces the value of the investment opportunity in all cases. Although on the one hand, greater discrete variation increases total volatility of the distribution margin –which, according to the option pricing theory leads *ceteris paribus* to an increase in the value of the option[18]–, on the other, it reduces the average simulated values of both the state variable and the underlying investment, the optimal result being to exercise the option on fewer occasions.

The reduction in the state variable is explained by the fact that the mean size of the jumps is null, $k = 0$, in which case the mean of the jump inversely depends on the value assigned to its volatility ($\mu_\pi = -\sigma_\pi^2/2$). Hence, increasing it reduces this average and, therefore, the value of the state variable. Further, upward limitation of the distribution margin intensifies the inverse relation between the value of the option and jump volatility, by strengthening downward variations of the state variable and restricting upward variations.

6. ANALYSIS AND DISCUSSION OF THE VALUATION RESULTS

Our study of Endesa's investment strategy in Latin America reveals that the option to expand into the Brazilian electrical energy business represented one of its sources of value. The question to be answered now is whether this source of value is sufficient to explain the decision taken by the Endesa board, and also to account for the fall in share price as a result of the loss of option arising from renegotiation of the

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performed for the alliance except in two aspects: i) a smaller market share for the Spanish company were it to be on its own, estimated to be 5.5% –equivalent to what would correspond to it through the alliance– and from which we reduce the market share corresponding to Endesa´s share in Cerj, 0.2%; and ii) the greater difficulty in making a successful bid given Enersis' experience in taking part in and being awarded leases in other electrical companies in the area, reflected in a 15% chance of success.

[18] Total volatility of the combined process using the Navas expression (2003) –which corrects that initially obtained in Merton (1976) – yields values of 9.18% and 16.93% when the jump dispersion takes values of 25% and 50% respectively.

alliance terms. To answer this question we analyse the relative weight of the value of the growth option, first in the extended NPV of Endesa's strategy and, second in stock prices.

6.1 The impact of the growth option embedded in the initial agreement

The data gathered in our study evidences that Endesa's NPV from the initial alliance agreement was clearly negative. The initial outlay foreseen to gain control of the Chilean holding came to 1,500 million dollars. Of this total amount, 1,000 million dollars in cash was used for the takeover bids for class A stocks and was obtained through debt funding. Taking a five-year reimbursement period and a mean tax rate of 35%, the current value of the tax saving generated by debt funding amounts to 75,591,731 dollars.[19] Finally the present value of the expected equity cash flows corresponding to Endesa from its share in Enersis *assets-in-place*, E^{AIP} = 899,080,811 dollars, plus the value of the tax shields proved lower than the outlay required for the investment, yielding a negative NPV of -525,327,458 dollars.

Nevertheless, the results to emerge when estimating the value of the opportunity to expand into Brazil provide a clear indication of the relevance of real options in this type of strategies. Figure 1 shows the extended NPV when adding to the NPV the estimated value of the growth option for different assumptions over the likelihood of making a successful bid or, alternatively, the premium to be paid. It can be seen how in certain reasonable cases the incremental value of the option reached by the alliance makes up for the negative NPV (yielding a positive extended NPV), and therefore justifies Endesa's strategy.

[Insert Figure 1]

In order to verify the relative weight of the incremental value of the option, we performed a comparative analysis with the estimated value of Endesa's *assets-in-place* per share. Applying the discounted cash flow model from equation (1), we obtain an estimate of the value generated by Endesa's assets-in-place, which amounted to 1,040,022,396 on the date of the initial agreement. Table 4 shows this result as well as the growth option value which should be attributed to each share.

[Insert Table 4]

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[19] To estimate the present value of tax shields we apply the model proposed in Fernández (2005) for the case where the market value of debt equals its book value.

On the this date, Endesa's stock value attributable to its assets-in-place only covered 67.18% of the price traded on the New York Stock Exchange, which was 21.0325 dollars. The incremental value of the expansion option in Brazil attributable to each share ranged between 0.72% in the most pessimistic of cases and 4.35% in the most optimistic.

Moreover, our valuation results concur with Endesa's stock price movements on the date the alliance was announced, as shown in Figure 2. The first column in Figure 2 illustrates the variation in the stock price 15 sessions before and 15 after the valuation date,[20] and the remainder the extended NPV attributable as a result of the investment in the Chilean holding.

[Insert Figure 2]

As can be seen, the difference between the average stock price on the days before and after the announcement of the alliance evidences a slight fall in the value of the electric company. This negative value is much closer to the extended NPV than to the conventional NPV, and approximately fits the values associated to the central scenarios analysed. This outcome reflects the effect of real options on the valuations made by investors when the alliance was formed with the Chilean group.

6.2 The impact of losing the option when renegotiating the alliance

Equally as interesting as testing the inclusion of real option value in stock prices is tracking the fall in stock prices when this type of right is lost. For this reason, we analyse the effect of the breakdown in the agreements between Endesa and Enersis at the end of October 1997. If investors consider real options in their valuation of stocks, Endesa stock prices should evidence the loss of the growth option in Brazil as provided by the alliance.

The breakdown in negotiations relieved the Spanish company from paying Enersis' insiders a further 250 million dollars, meaning that the total amount paid for a share in Enersis was 1,250 million dollars. Conventional NPV resulting from redefining the terms of the investment after renegotiation of the alliance improves in comparison to that obtained at the time the agreement was formalised although the net result is still negative, now showing a figure of -274 million dollars.

Despite an improvement in the investment's conventional NPV, Endesa's stock

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[20] A reduced range is shown in order to limit the presence of other events which may impact stock prices.

price fell after renegotiation of the agreement, reflecting the loss in value of the growth option. To analyse this in greater depth we recalculated the value of Endesas' equity attributable to its assets-in-place using equation (1).

Estimated values of Endesa's *assets-in-place* at the time the agreement broke down together with the difference compared to previous estimations are shown in Table 5. The value of each stock attributable to its assets-in-place is significantly lower than its market value, around 18 dollars per share on the days prior to renegotiation. This represents 76.8% of the price, higher than the 67.18% recorded when the agreement was formally signed and provides an indication of the loss in value attributable to the growth option.

[Insert Table 5]

The difference between the NPV of the investment without options and the extended NPV per Endesa share is also reflected in the variation in the stock price. Figure 3 shows that the values obtained for this difference for the main scenarios are similar to the variation in Endesa's stock prices 15 sessions before and after the valuation date. This result provides empirical support for the relevance investors attached to real options in their valuations, even though in this case it is the loss of the growth option which is reflected in the fall of stock prices.

[Insert Figure 3]

7. CONCLUSION

Our analysis of a real investment case presented throughout this paper has provided new evidence concerning the relevance of sources of value other than direct cash flow. We have found that the value of a growth option is sufficient to justify the investment strategy made at the time by Endesa, and provides a clearer insight into market price fluctuations.

Information available reveals that Endesa's investment in Enersis evidenced a clearly negative NPV. Yet equally as clear as this negative result is the strategic nature of a commitment which yielded the opportunity to manage the Chilean holding and placed the alliance as leader in the sector in various countries throughout the continent. The presence of sources of value other than expected cash flow is clearly manifest through the option to expand which the alliance would secure for itself over power distribution in Brazil.

For Endesa the value generated from the alliance does not emerge from acquiring an option to expand which it already held by itself, but from improved conditions for investment opportunities. Estimating the incremental value of the option to expand highlights the importance of this source of value and serves as empirical evidence to support the real options approach.

The results obtained do not allow us to refute the hypothesis that Endesa's market value includes the option to expand. Estimation of the relative importance of the value of the growth option in Brazil compared to Endesa's market value and the value of its *assets-in-place* on the date of the initial agreement highlights the relevance of this source of value. Moreover, it indicates the possible existence of other real options linked to it or other lines of business the firm may be involved in. We evidence that the changes in Endesa's stock prices on the days prior and subsequent to the agreement reflect our estimations of the extended NPV.

The loss of the growth option as a result of renegotiation of the agreement has provided us with further evidence with which to appraise our hypothesis of the importance of the option. Analysing the difference between market values of Endesa accounted for by its *assets-in-place* before and after renegotiation reveals how less weight is attached to this growth option. The fall in Endesa's stock price also reflects the loss in value attributed by investors to expansion opportunities to arise from the alliance with the Chilean group.

Taken as a whole, the evidence gathered and assessed in this work contributes to furthering the empirical evidence to support the relevance of real options as a source of value in corporate investment. Specifically, our research broadens the scope of case studies by exploring new areas of business. Despite the differences observed in the nature of options to expand in the power sector, the underlying assets as well as the state variables on which cash flows depend, their relevance in terms of value and how they are reflected in stock prices bear out the results reported in previous literature for areas such as oil or technology.

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Tables and Figures***

Table 1. *Value of Enersis' stocks attributable to its Assets-in-place*

Date	K	Beta	BPA I/B/E/S estimate	E_0^{AiP} (Mill. of US dollars)	Endesa's share (Mill. of US dollars)
30/07/1997	8.70%	0.587	0.0260	3 096.0	899.1
30/10/1997	8.78%	0.650	0.0263	3 099.4	900.1

The value of assets-in-place is approximated by the discounted cash flow model, where equity cash flow is estimated by net income. Net income is considered to grow perpetually at a constant annual rate equal to estimated inflation. Risk-adjusted discount rate is taken from the CAPM. Market risk premium is estimated at 4.23%. The risk free rate is 6.22 and 6.03%, respectively, on the initial date of the agreement and on the negotiation date; while the beta coefficients on these dates are 0.587 and 0.65 respectively. Net income per share is the mean consensus from the I/B/E/S base, provided by *Datastream* two months before and ten after the valuation date. The annual inflation rate applied is 3%.

Table 2. *Main parameters in preceding privatisations*

Firm	Date of tender	Cost of sale (Millions of US dollars)	Energy distributed (GWh*)	% Tendered
Escelsa	July 1995	387	4 696	50
Light – SESA	May 1996	2 391	21 170	56
CERJ	November 1996	588	5 458	76
TOTAL		3 366	31 324	

Source: Economic Commission for Latin America (CEPAL).
* According to SI Units one gigawatt is equivalent to 1 000 megawatts.

Table 3. *The value of the option to expand into Brazil*
(Values in Millions of US dollars)

	For Endesa-Enersis alliance			Incremental option value for Endesa		
	No regulatory risk	25% Regulatory risk	50% Regulatory risk	No regulatory risk	25% Regulatory risk	50% Regulatory risk
Panel A: Values estimated from the overpricing model						
10%	1 699.1	1 471.5	1 218.9	950.3	825.3	685.3
20%	1 319.1	1 103.9	906.7	691.6	575.1	472.8
30%	974.9	825.5	657.5	457.4	385.6	303.2
40%	651.8	548.2	440.7	237.4	196.8	155.6
50%	410.4	305.4	277.9	73.1	31.5	44.8
Panel B: Values estimated from the likelihood model						
66% Likelihood	1 368.2	1.121.4	870.6	725.0	587.0	448.2
50% Likelihood	1 036.5	907.2	734.2	499.3	441.2	355.4
33% Likelihood	684.1	598.8	484.6	259.4	231.2	185.5

The first three columns show the growth option value for the Endesa-Enersis alliance on an underlying asset representing 7.5% of demand for electricity in Brazil. The remainder columns show the difference between the option value for the Endesa-Enersis alliance and the value of the same option owned by Endesa on its own (with a 15% likelihood of making a successful bid and a maximum market share of 5.3%).

The option value depends on two state variables. The *distribution unit margin* evolves following a mixed jump-diffusion process. The drift of the Brownian-Geometric motion is 8.05% and volatility is 4.57%. For discontinuous variation we consider volatilities of 25 and 50%, with an average number of annual jumps of 0.1. The initial value of the variable is 27 dollars per megawatt distributed. The *demand for electricity* evolves following a mixed process in which the size of the proportional jump is known for certain (-15%) and the average number of annual jumps is 0.02. The continuous parameters are 7.60% for the drift and 4.34% for volatility. The initial value of the variable is 277.685 gigawatts.

The option is a quasi-American type call option and may be exercised each six months over a five-year period. Exercising the option is analysed from a twin perspective. Panel A shows a premium of between 10 and 50% to be paid on the lowest price foreseen in the bidding. In panel B we consider an exercise price equal to the minimum set for the bidding and apply a likelihood of a successful bid by Endesa-Enersis of between 33 and 66%.

The number of simulated paths for each state variable is 800 000, split into two equal groups: 400 000 paths (200 000 direct estimations + 200 000 antithetical) to estimate the optimal exercise frontier; and another 400 000 paths (200 000 + 200 000) to estimate the option value.

Table 4. *Value per share of Endesa's Assets-in-place and incremental value per share of the alliance's growth option (Values in US dollars)*

Endesa's assets-in-place value per share				
K	Beta	EPS I/B/E/S estimate	P.V. of cash flows	PV per share
10.68%	1.054	1.09	14 695 292 828	14.130

Incremental value per share of the growth option for Endesa			
	No regulatory risk	25% regulatory risk	50% regulatory risk
Panel A: Values estimated from the overpricing model			
10%	0.91373	0.79356	0.65895
20%	0.66502	0.55293	0.45459
30%	0.43976	0.37078	0.29150
40%	0.22829	0.18923	0.14960
50%	0.07027	0.03033	0.04305
Panel B: Values estimated from the likelihood model			
66% Likelihood	0.69714	0.56442	0.43099
50% Likelihood	0.48006	0.42422	0.34172
33% Likelihood	0.24941	0.22235	0.17834

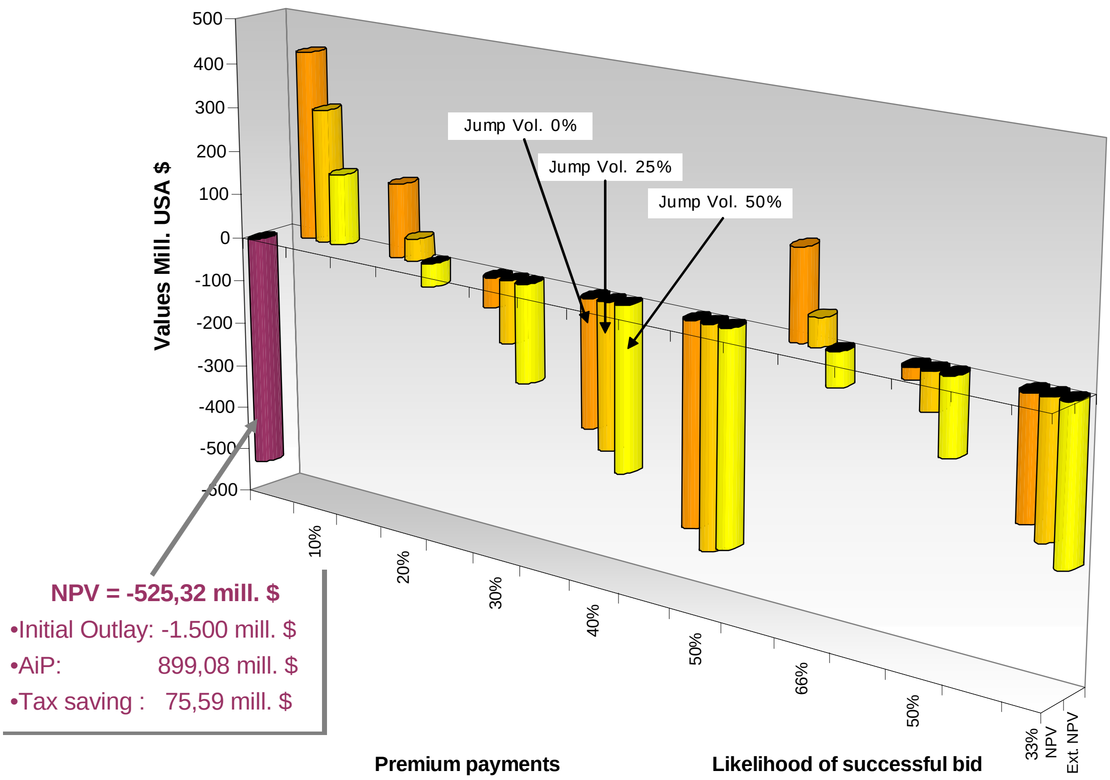
Endesa's value per share attributable to its assets-in-place is estimated from the discounted cash flow model, where equity cash flow is estimated by net income (equation 1), taking into account that the number of shares on the date of the initial agreement was 1 040 022 396. Risk-adjusted discount rate is taken from the CAPM. The risk free rate is 6.22%; market risk premium is 4.23%; and the beta coefficient, 1.054. Net income per share is the analysts' mean consensus from the I/B/E/S base, provided by *Datastream* two months before and ten after the valuation date. The annual inflation rate applied is 3%.
The value of the growth option shown represents the incremental value for the Endesa derived from the difference between investing in Brazil through its alliance with Enersis rather than investing on its own.

Table 5. *Variation in Endesa's stock price attributable to its Assets-in-place (Values in USA dollars)*

K	**Beta**	**EPS I/B/E/S Estimate**	**P.V. of cash flows**	**P.V. per share**
Endesa's *Assets-in-place* after renegotiation				
10.73%	1.178	1.08	14 544 000 929	13.984
Difference. After – Before renegotiation				
0.05%	0.0564	-0.01	-151 291 899	-0.145

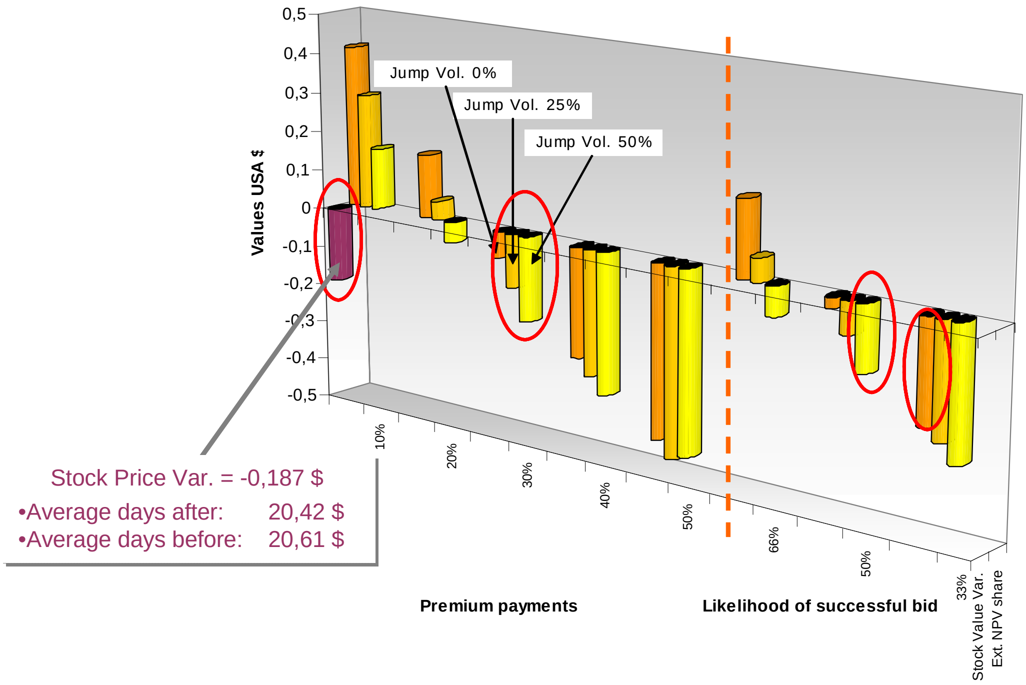
Endesa's value per share attributable to its assets-in-place is estimated from the discounted cash flow model, where equity cash flow is estimated by net income (equation 1), taking into account that the number of shares on the date of the initial agreement was 1 040 022 396. Risk-adjusted discount rate is taken from the CAPM. The risk free rate is 6.22%; market risk premium is 4.23%; and the beta coefficient, 1.054. Net income per share is the analysts' mean consensus from the I/B/E/S base, provided by *Datastream* two months before and ten after the valuation date. The annual inflation rate applied is 3%.
The final row shows the difference between Endesa's values per share attributable to its assets-in-place after renegotiation of the agreement and on the date it was formalised.

Figure 1. *NPV and extended NPV of Endesa's investment strategy*
(Values in millions of US dollars)



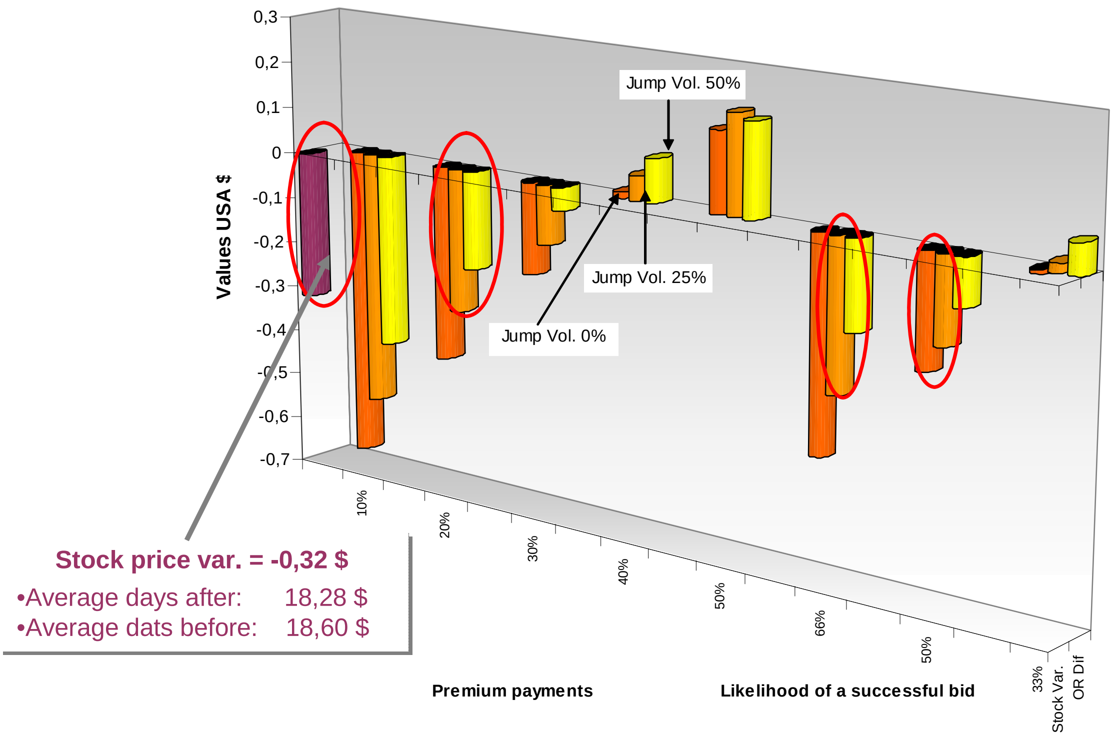
The first column shows the NPV of Endesa's investment in Enersis. The following columns show the extended NPV considering the value of the option to expand in Brazil. The value of the growth option shown corresponds to the incremental value for Endesa of the difference between the option to invest in Brazil through its alliance with Enersis rather than investing on its own. The premium on the reference value and the likelihood of a successful bid provide the various risk scenarios in the allocation of the tender.

Figure 2. *Variation of Endesa's stock price before and after the agreement and extended NPV attributable to each share*
(Values in dollars)



The first column shows the variation in the price of Endesa stocks on the NYSE 15 sessions before and 15 sessions after the date of the initial agreement.
The following columns show the extended NPV attributable to each Endesa. The number of stocks comes to 1 040 022 396.

Figure 3. *Variation in the stock price of Endesa and difference between the extended NPV of the modified agreement and the extended NPV of the initial alliance (Values in dollars)*



The first column shows the variation in the stock price of Endesa on the NYSE 15 sessions before and 15 after the renegotiation date.

The following columns show the Endesa's value per share attributable to the difference between the extended NPV of the investment after renegotiation (coinciding with the conventional NPV) and the extended NPV of the investment in accordance with the initial terms of the agreement. The number of shares comes to 1 040 022 396.