Rating and ranking firms with fuzzy expert systems: the case of Camuzzi

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Abstract. In this paper we present a real-life application of a fuzzy expert system aimed at rating and ranking firms. Unlike standard DCF models, it integrates financial, strategic and business determinants and processes both quantitative and qualitative variables. Twenty-one value drivers are defined, concerning the target firm (strategic assets in place and expected financial performance), the acquisition (synergies, quality of management) and the sector (intensity of competition, entry barriers). Their combination via "if-then" rules leads to the definition of an output represented by a real number in the interval [0,1]. Such a number expresses the value-generating power of the target firm inclusive of synergies with the bidder (*Strategic Enterprise Value*). The system may be used for rating and ranking firms operating in the same sector. A regression analysis using hostile takeovers multiples may be employed to translate the score into price. The real-life case refers to Camuzzi (a natural gas distributor), acquired by Enel, the Italian ex monopolist of electric energy.

Keywords. Corporate finance, firm, rating, ranking, expert system, fuzzy, evaluation.

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Introduction

This paper presents an expert system aimed at evaluating firms. To this end, the lines of reasoning of experts are replicated taking into account financial, business, strategic determinants. The approach followed results in a method of rating and ranking firms. The model presented may also be used to inform about the impact of a particular management's decision on value creation or to compensate managers on the basis of their performance. The model has been applied to the case of Camuzzi, recently acquired by Enel, the Italian ex monopolist of electric energy.

The evaluation derives from the use of "if-then" rules in a fuzzy-logic environment. While our approach is just a first attempt to develop a new methodology for appraising firms and business units, we think that this path is fruitful for dealing with complex situations where a great number of value drivers must be taken into account, both qualitative and quantitative, and/or where explicit account of their interrelations must be taken for a better description of the evaluation process.

While alternative to discounted-cash-flow (DCF) techniques, the structure of the model we propose is logically consistent with them as well as with a strategic management conceptual framework. As for DCF techniques, the standard computation of the enterprise value is given by the present value of the free cash flows to firm (FCFF):

$$\text{Firm Value} = \sum_{t=1}^{\infty} \frac{\text{FCFF}_t}{(1+\text{WACC})^t} = \frac{\text{FCFF}}{\text{WACC} - g}$$

where $\text{FCFF}_t = \text{FCFF}_{t-1}(1+g)$, $\text{FCFF} := \text{FCFF}_1$, g=growth rate, WACC=Weighted Average Cost of Capital. The WACC is an opportunity cost, representing the foregone return of alternatives businesses in the same class of risk (usually in the same sector), and is an increasing function of risk. The value is also increasing with respect to both FCFF and g, and it is decreasing with respect to risk. An equivalent way of computing the market value of the firm is the APV method introduced by Myers (1974) (see Fernández, 2002):

$$\text{Firm Value} = \sum_{t=1}^{\infty} \frac{\text{FCFF}_t}{(1+k_U)^t} + \text{DVTS} = \frac{\text{FCFF}}{k_U - g} + \text{DVTS}$$

where k_U=cost of equity of the unleveraged company, DVTS=Discounted Value of Tax Shield. Consistently with this approach, the output of our expert system depends on free cash flows and growth (positive correlation), as well as on operating risk (negative correlation).

Unfortunately, the DCF methods are black boxes where the determinants of FCF and g are not highlighted and where risk appears only implicitly in the rate k_U (or WACC), whereas our model explicitly takes account of these variables. Further, the DCF methodology seems to be unsuited for quantification of synergies and, if a quantification is ever attempted, the analyst just raises discretionally the FCF. In our approach, we explicitly consider synergies as an important determinant of rating, and explicit relations between synergies' determinants are stated via a specific rule block (see next section).

In other terms, the rigorous way of discounting cash flows adopted by the DCF approach is offset by a nontransparent way of fixing the value for FCFF, g and the rates k_U or WACC. The determination of these inputs is left to the analyst's or managers' arbitrariness, so causing possible manipulations of data. Our model does retain the conceptual frame of the DCF approach, but integrates it with strategic management theories. For example, the presence of *Resources and Skills* as a value driver is coherent with the findings of the Resource-based view according to which a

variety of peculiar skills and intangible abilities can greatly affect a firm's performance (Barney, 1986, 1991, 2001; Grant, 1991; Levinthal, 1995). Likewise, the variables Barriers, Customer Concentration and Supplier Concentration give expression to Porter's (1980, 1985) industry analysis.

The integrated view we propose is also consistent with bounded rationality in that pre-eminent importance is given to recognizing limited computational capabilities and presence of constraints. For example, the presence in our model of the value driver *Management Quality* is consistent with the literature on Top Management Teams (TMTs) which claims that managers and employees differ in expertise so that the quality of the TMT's decisions substantially influence the performance of the firm (Bromiley, 2005, p. 78. See also Simons, Pelled and Smith, 1999). Likewise, the presence of the variable *Technology* conforms to the finding of most studies of organizational learning according to which owning a specific technology is valuable because transferring technologies is difficult and takes time even in the same sector (Bromiley, 2005, p. 84).

In addition, the very formal structure of our model is consistent with a behavioral perspective in strategic management: By creating nontrivial connections among variables and expressing relationships via 'if-then' implications we try to give formal clothing to the idea that a firm is a complex system made of physical, intellectual and financial assets, knowledge and skills of management and employees, which is grounded on complex interrelations (see Bromiley, 2005, for relationships among bounded rationality, Resource-based view, Porter's industry analysis, and for a behavioral foundation of strategic management).

The system processes absolute as well as relative variables. The former are defined relative to the sector in which the firm operates (e.g., *Operating Leverage* and *ROI*), the latter are firm-specific and do not relate to the other firms in the sector (e.g., *Management*, *Resources and Skills*). The rating is then a mix of absolute/relative indexes and should be interpreted in connection with the purposes for which it is used.

The final output is a rating in [0,1], and serves several uses:

(a) **Ranking firms in the same sector**. All the firms of a sector are rated with the expert system, and then ranked according to groups expressing their value-generating power.
(b) **Comparing business units of a firm.** The business units of a firm are compared through the relative rating.
(c) **Measuring the impact of the firm's possible policies and strategies on value creation**. For each different policy a rating of the firm is provided and the decision is taken following the highest rating.
(d) **Evaluating the impact of particular decisions on value creation**. The firm is first rated assuming a particular alternative is undertaken, and then it is rated assuming that alternative is rejected. The decision will be taken which corresponds to the higher score.
(e) **Rewarding and compensating managers**. The firm or business unit is rated at the beginning and at the end of a period to compute the increase/decrease in the value-generating power and therefore assess the managers' performance.
(f) **Pricing firms**. The rating may be translated into price through a statistical procedure, in case an acquisition is under consideration (see section 5).

1. The expert system

An expert system is a software addressed to achievements usually performed by a human expert. It consists of a knowledge base and an inferential engine. If a question is asked, the system will try to infer the answer from the knowledge base, using logic and the heuristics of the inferential engine. The knowledge must be represented in symbolic forms so as to be stocked and used by a computer. The most common method to this end is to use rule blocks. For example, a simple rule based on conditional ("if-then") implications is the following:

IF market forecasts are favorable
AND (the quality of the products is very high
OR the intensity of rivalry is low),
THEN prospective profits are high.

Linguistic attributes such as "favorable" "high", "very high", "low" and such are given a fuzzy quantification through the construction of fuzzy numbers. Figure 1 shows the fuzzy number of the variable *Reinvestment Rate*.

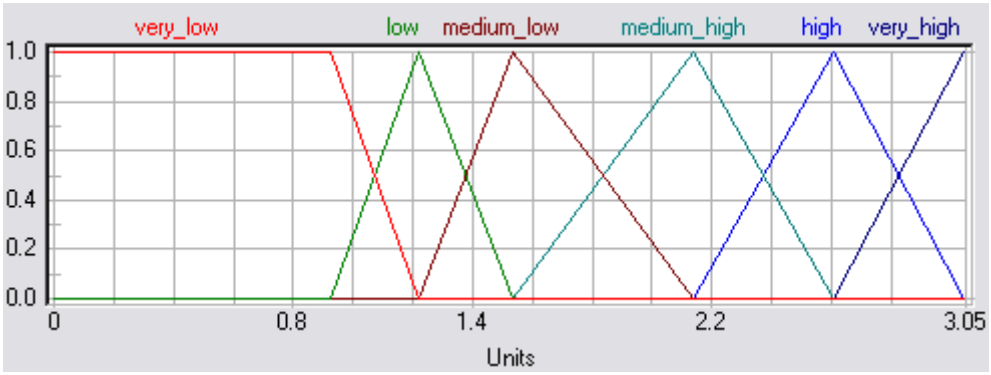

Figure 1. *Reinvestment Rate*

The *x*-axis collects all possible numerical values for the *Reinvestment Rate*, whose unit of measure is given by

$$\frac{\text{capital expenditures} - \text{depreciation} + \Delta \text{ non cash working capital}}{\text{EBIT}(1 - \text{tax rate})}$$

(see section 6 for a detailed description of every input and every intermediate variable). The *y*-axis collects the degrees at which a linguistic attribute is activated (membership degrees). The very-low attribute is represented by a trapezium (its basis ranges from 0 to 1.2) and the others linguistic attributes (low, medium-low, medium-high, high, very-high) are depicted as triangles (their bases range, respectively, from 0.9 to 1.5, from 1.2 to 2.15, from 2.15 to 3.05, from 2.6 to 3.05). For example, if the evaluator fixes a reinvestment rate of 1, this means that it is considered very-low at a degree of 0.75 and low at a degree of 0.25. If instead the reinvestment rate is fixed at 2.8, then it is considered high at a degree of 0.55 and very-high at a degree of 0.45.[2]

[2] The sum of the membership degrees need not be 1 (they are not probability measures); it just depends on the shape of the fuzzy number the evaluator chooses for describing the linguistic attributes.

Each linguistic attribute of each value driver is described by a fuzzy number. The shape of the fuzzy number (triangle, trapezium, or other regular or irregular geometric figures) and the number of linguistic attributes is left to the subjectivity of the expert constructing the model.

As for the qualitative value drivers (such as *Entry Barriers* and *Management Quality*), the *x*-axis is normalized to the interval [0,1] and the determination of the appropriate value should be left to the judgment of the evaluator, whose specific experience in the field and fairness are necessary conditions for a correct attribution.[3] For example, in the Camuzzi case we have decided to activate the variable *Management Quality* at a degree of 0.8. The reason is to be found in the good track record of the incumbent target's management team (under the assumption of no substitution). We have abstained from giving the maximum score of 1 because of a lack of international experience of its management team (excepting the Argentine market). In view of the global context in which the new company will have to operate we have therefore considered the presumable lack of wide international experience as a minus.

As for the quantitative value drivers a more articulated procedure has been employed: a peer group of companies, belonging to the same industrial sector and possibly operating on the same markets, have been isolated (we have used financial data of some of the biggest Italian utilities firms: Acea, Acsm, Hera, Meta, Agea, Acegas-Aps, Agac, Amps, Tesa Piacenza, Aem Torino, Amga, Aem, Asm, Bas Bergamo, Snam, Enel) and, for each such variable, the value in each company has been determined.[4] The ranges of the linguistic attributes of all the quantitative drivers in the model can be easily defined through a statistical computation of the distribution of values around industry's median values. As an example, consider the variable *ROI*, which is a determinant (alongside *Reinvestment Rate*) of the intermediate variable *Growth Rate* (see Diagram at the end of the paper). Table 1 shows the statistical distribution of this variable in the sample of selected utilities. The interval of variation we have found is 0-14%. Dealing with sextiles we have consistently considered six linguistic attributes: very-low, low, medium-low, medium-high, high, very-high (the resulting fuzzy numbers are represented in Figure 2). We have then fixed 5.1% as the *ROI* of Camuzzi, which represents the pre-acquisition value of the *ROI* (see section 2). Looking at Figure 2, we see that the *ROI* of Camuzzi is very low at a degree of 1.

Table 1. Utilities sector: ROI distribution

	ROI
Sextile 1	5.5%
Sextile 2	8.4%
Sextile 3	9.1%
Sextile 4	9.8%
Sextile 5	10.1%
Sextile 6	13.2%
Camuzzi's value	**5.1%**
Variation's interval	**(0-14%)**

[3] The presence of subjective judgments is not a drawback but a strength of the model. The system is just aimed at replicating the very line of reasoning of an expert or a panel of experts.

[4] To this end, financial databases can be used (e.g. Bloomberg, Barra, Datastream for listed companies, Aida for private ones). We have used Bloomberg.

Once decided which inputs are to be used as value drivers, once constructed the corresponding fuzzy numbers, once fixed the appropriate value in the *x*-axis for each value, such a value is fuzzified with the fuzzy numbers and a modular approach is triggered, according to which the twenty-one value drivers are combined into groups to create intermediate variables via the activation of rule blocks. The intermediate variables in turn aggregate to give rise to other intermediate variables via other rule blocks, and so on until two intermediate outputs are reached: *Enterprise Value* (see Diagram at the end of the paper) and *Synergies*. The latter two are in turn combined to obtain the final output. This output, being itself represented by a fuzzy number, is automatically defuzzified by the system providing a 'crisp' value in the interval [0,1] (for details on the functioning of the system and the defuzzification procedure, see von Altrock, 1997).[5]

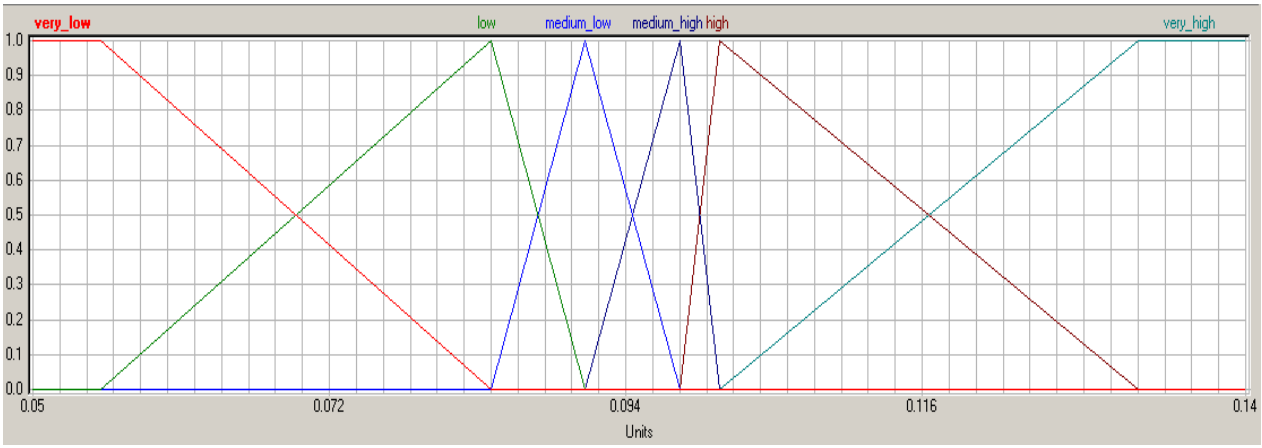

Figure 2. *ROI*

The final output of our model represents the value-creation power of the firm and is here called *Strategic Enterprise Value*. As anticipated, it consists of two fundamental blocks:

(1) Camuzzi's *Enterprise Value*
(2) *Synergies* realizable through the merger between Enel and Camuzzi.

The *Strategic Enterprise Value* of the target is then a function of *Enterprise Value* and *Synergies* (see Figure 3)

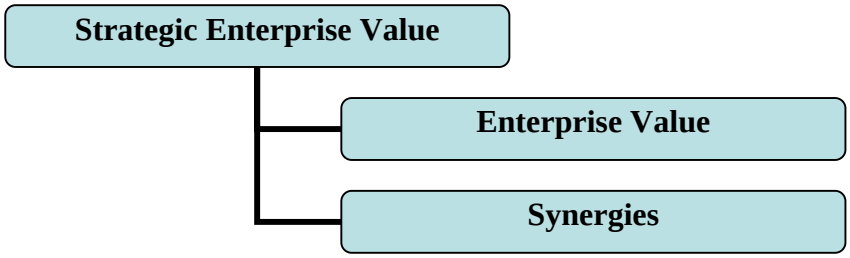

Figure 3. *Strategic Enterprise Value* as a function of *Enterprise Value* and *Synergies*

[5] The expert system may also be read backward, with the output being interpreted as a function of intermediate variables, each of which is in turn function of intermediate variables, and so backward until the input variables (the value drivers) are reached

The way the *Strategic Enterprise Value* is obtained from these two variables is given by the rule block represented in Table 2.
The intermediate output *Synergies* depends on three variables: *Complementarities*, *Economies of Scale*, and *Market Share* (see section 6 for description of these inputs).

Table 2. *Strategic Enterprise Value* rule-block

IF		**THEN**
Enterprise Value	**Synergies**	**Strategic Enterprise Value**
Very_low	Very_low	Very_low
Very_low	Low	Low
Very_low	Medium	Low
Very_low	High	medium_low
Very_low	Very_high	medium_low
Low	Very_low	Low
Low	Low	Medium_low
Low	Medium	Medium_low
Low	High	Medium
Low	Very_high	Medium
Medium	Very_low	Medium_low
Medium	Low	Medium
Medium	Medium	Medium
Medium	High	Medium
Medium	Very _high	Medium_high
High	Very _low	Medium
High	Low	Medium
High	Medium	Medium_high
High	High	Medium_high
High	Very _high	High
Very_high	Very _low	Medium_high
Very_high	Low	Medium_high
Very_high	Medium	High
Very_high	High	High
Very_high	Very _high	Very _high

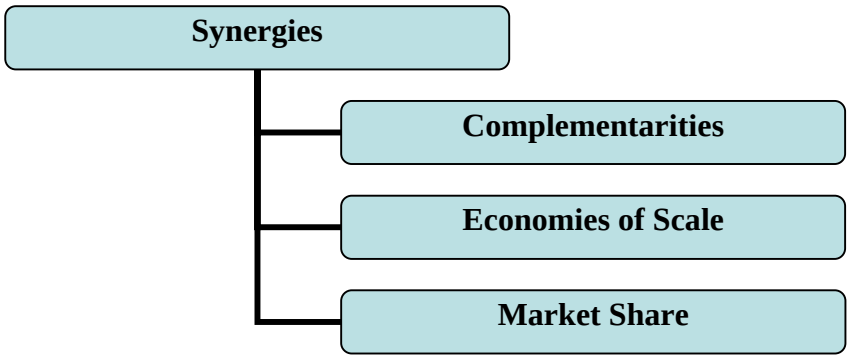

Figure 4. Synergies as a function of *Complementarities, Economies of Scale* and *Market Share*

The intermediate output *Enterprise Value* is instead a function of *Free Cash Flow to Firm*, *Growth Rate* and *Operating Risk*. Each of the latter are in turn function of other variables, as the Diagram at the end of the paper shows. All intermediate variables are reached via "if-then" rule blocks, analogously to the one described in Table 2.

2. Notions of value

There are various possible meaning attachable to the term "value". We focus on the following:

Stand-alone Value. It is the value of a firm considered standing-alone, without consideration of possible synergies (nor other interrelations with the buyer).

Status-quo Value. It is the value of a firm with no consideration of possible additional value from the bidder's potential through a managerial optimization (i.e. no management change, no increased efficiency in operating working capital investment etc.).

Optimal Value. If we add to the *Status-Quo Value* the potential value attainable through a managerial optimization then we obtain an *Optimal Value* which is expression of a different and better management team. In the corporate finance literature the difference between the two values is labelled *value of management change* or *expected value of control*: [6]

EXPECTED VALUE OF CONTROL= Optimal Value – Status-Quo Value.

Control premiums are usually paid for controlling companies. From the point of view of shareholders the control premium paid should be smaller or equal to the value of control. If the target company is already optimally managed no control premium should be paid.

Strategic Value. It is the value of the firm inclusive of the value of Synergies.

[6] "The value of controlling a firm has to lie in being able to run it differently (and better). Consequently, the value of control will be greater for poorly managed firms than well run ones" (Damodaran, 2005, p. 60). "If we estimate a value for the firm, assuming that existing management practices continue, and call this a *status quo value* and re-estimate the value of the same firm, assuming that it is optimally managed, and call this estimate the *optimal value*, the value of changing management can be written as: Value of management change = optimal firm value – status quo value" (Damodaran, 2005, p.16).

Core-Business Value. It is the value of the company excluding cash, marketable securities, real estate, secondary businesses (e.g. Piacenza Calcio for Camuzzi) and non operating assets, which must be considered separately. The notion of free cash flow to firm we employ does not include earnings on secondary assets and interests on securities.

Unlevered Value. The value of the firm as if there were no debt, as opposed to the levered enterprise value, where capital structure is taken into account.

The notion of *Enterprise Value* employed for Camuzzi is: Stand-alone, Status-quo, Core-business, Unlevered (SSCU).

Therefore, we have assumed no substitution of management after the purchase of Camuzzi by Enel. The control premium has consequently been neglected. This means that we have fixed the inputs of the system taking into consideration the current performance, not the best possible one attainable with an optimal management. A relative stability with the past has also been postulated. As an unlevered stand-alone status-quo and core business value, Camuzzi's *Enterprise Value* represents the minimum fair value attributable to Camuzzi, with no consideration of capital structure (and therefore before computation of the tax shield). If a price is extracted from this value (see section 5) one obtains the lowest price payable to acquire the business (floor price) with no consideration of the tax shield's value.

Although we have not considered the additional value from managerial optimization[7] this can be easily included in the system. One just has to change those input variables that directly (e.g. *Management Quality*) or indirectly (e.g. *Expenditures in R&D*, *NonCash Working Capital*) affect the expected value of control. With the new inputs corresponding to optimized management a new *Enterprise Value* is obtained by the system, whose meaning will be Stand-Alone, Optimal, Core-business, Unlevered (SOCU). This SOCU Value is therefore an expression of the best possible exploitation of the firm's assets' in a given competitive context. In terms of operating actions, the managerial optimization should lead to increasing cash flows from assets in place (e.g. improving operating efficiency, asset redeployment, reducing working capital investment), increasing the expected growth or lengthen the high growth period, and reducing the operating risk by working on the manoeuvrable risk components (e.g. reducing operating leverage and/or the product/services discretionary through marketing investments). If transformed in a price, this optimal value provides the highest price payable to acquire the operating assets of the target (ceiling price).

As seen in section 1, the *Enterprise Value* and the value of *Synergies* have been aggregated to create what we call the *Strategic Enterprise Value*. If one adds the expected value of control and the value of tax shield, alongside marketable securities and non-operating assets, one finds the Firm Value of the target (Table 3).

[7] The reason is not only due to a lack of information, but also to the fact that a status-quo value is highly informative, because it furnishes a minimum threshold for a firm.

Table 3. Strategic Enterprise Value

SSCU Enterprise Value	SSCU Enterprise Value
+ Synergies	+ Expected Value of Control
Strategic Enterprise Value	**SOCU Enterprise Value**
+ Expected Value of Control	+ Synergies
Strategic Enterprise Value (Optimal)	**Strategic Enterprise Value (Optimal)**
+ Value of Tax Shield	+ Value of Tax Shield
+ Cash and marketable securities	+ Cash and marketable securities
+ Holdings and other non-operating assets	+ Holdings and other non-operating assets
Firm Value	**Firm Value**

As shown in the left column of Figure 3, we have not considered the *Expected Value of Control* nor the value of tax shield. As seen, the former may be taken account by the expert system by changing the value of the inputs related to management performance, whereas the value of the latter may be considered by constructing an expert system whose output is integrated (via a rule block) with both *Enterprise Value* and *Synergies* (see Figure 5).[8]

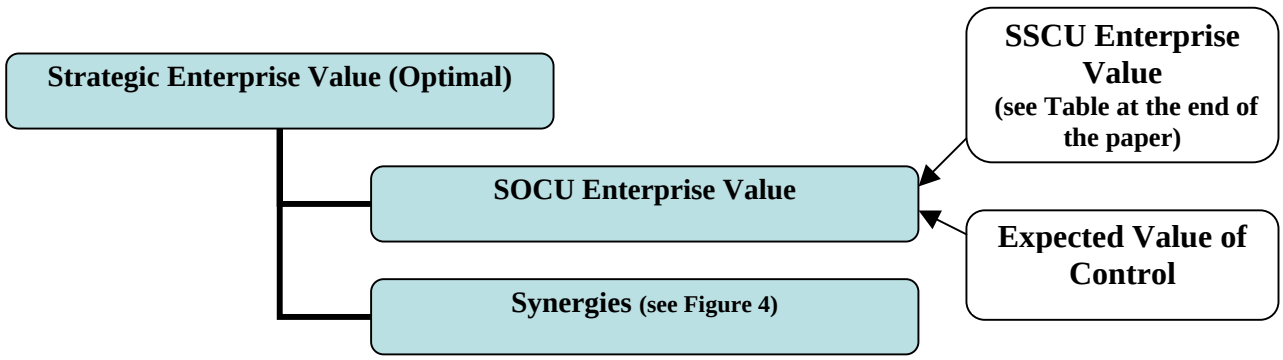

Figure 5. Strategic Enterprise Value (Optimal)

[8] An example of evaluation of a levered firm with a fuzzy expert system can be found in Magni, Malagoli and Mastroleo (2006).

3. The results

To obtain the *Strategic Enterprise Value*, we have fixed a value for each of the twenty-one value drivers described in section 6.1, excepting three of them: *Acquisition*, *Competitive Rivalry*, *Economies of Scale*. The latter have been given two different values, so obtaining two different scenarios (see Table 4). This choice is due to our incomplete information about (a) the evolution of the sector's boundaries and competition in the future, (b) the managerial actions following the bid, (c) data on scale economies.

As for *Acquisition*, the recent liberalization of the utilities sector in many European countries has led us to predict an elevated flow of acquisitions in the future. Being Camuzzi an important player on the Italian and European market, it is highly probable that it will be particularly active on acquisitions in the future. We have consequently attributed a value of 0.7 in the first scenario and of 0.85 in the second scenario. The higher value is evidently associated with a smaller score for the *Free Cash Flow to Firm* in the second scenario (0.44) than in the first one (0.5). The reverse occurs to the *Reinvestment Needs*, which rise from 0.13 to 0.23.

As for *Competitive Rivalry*, in the European utility sector it is not easy to predict the intensity of competition which will characterize the market in the future, but it is plausible that it will not be low because of a persistent attractiveness of the business (rich cash generation and relatively low risk profile), which will probably attract new comers or lead incumbents to contending new markets. This justifies our assumptions of 0.8 and 0.5 respectively. The higher score attributed in the first scenario explains the higher *Business Risk* and the higher *Operating Risk* value in the first scenario.

As for the variable *Economies of Scale*, in the first scenario we have fixed a rather high value of 0.8 (good potential opportunity to share SG&A costs), while in the second we have fixed a medium value of 0.5, which in our view is the most plausible assessment due to the restrictions of the Italian labour law on dismissing.

It is worth noting that the value of *Synergies* in the second scenario decreases from 0.79 to 0.65 due to the decrease in *Economies of Scale*. Camuzzi's *Enterprise Value* decreases from scenario 1 to scenario 2, but the decrement is negligible: the lower expected FCFF due to the higher *Reinvestment Needs* is almost entirely offset by the lower *Operating Risk*, due to a lower *Business Risk*, which induces a lower.

The two final ratings for Camuzzi's *Strategic Enterprise Value* (0.57 in the first scenario, 0.45 in the second one) can be considered as the lower and upper limit of a fork of values for the potential buyer (Enel). Being the final output normalized at [0,1] the results show that Camuzzi's acquisition, in a status-quo valuation's perspective, has a medium value-creation power for Enel. If one were to add the value of control one would reach a higher score. i.e. a higher value-creation power, which, if commuted into price, would lead to the highest price payable by Enel for Camuzzi (prior to consideration of tax shield, marketable securities and non-operating assets).

Table 4. The input variables (value drivers) for Camuzzi

Inputs (value drivers)	Scenario 1	Scenario 2
Acquisition	**0.7**	**0.85**
Capital Expenditures in R&D	0.02	0.02
Competitive Rivalry	**0.8**	**0.5**
Complementarities	0.85	0.85
Consumer Price Sensitivity	0.65	0.65
Customer Concentration	0.1	0.1
Economies of Scale	**0.8**	**0.5**
Entry Barriers	0.9	0.9
Investment in NonCash Working Capital	–0.05	–0.05
Management Quality	0.8	0.8
Market Share	0.8	0.8
Net Capital Expenditure	0.02	0.02
Operating Leverage	0.07	0.07
Processes Efficiency	0.9	0.9
Reinvestment Needs	2.17	2.17
Resources and Skills	0.9	0.9
ROI	0.05	0.05
Sensitivity to Macroeconomic Variables	0.65	0.65
Supplier Concentration	0.9	0.9
Tax Rate	0.33	0.33
Technology	0.9	0.9

Table 5. The intermediate variables for Camuzzi

Intermediate Variables	Scenario 1	Scenario 2
Bargaining Power	0.5	0.5
Business Risk	**0.75**	**0.5**
FCFF	**0.5**	**0.44**
Growth Rate	0.25	0.25
Operating Costs	0.07	0.07
Operating Margin	0.63	0.63
Operating Risk	**0.46**	**0.33**
Product Quality	0.9	0.9
Reinvestment Needs	**0.13**	**0.23**
Revenues	0.6	0.6
Specific Risk	0.36	0.36
Strategic Risk	0.08	0.08

Table 6. Camuzzi's Enterprise Value, Synergies and Strategic Enterprise Value

	Scenario 1	**Scenario 2**
Enterprise Value	0.47	0.44
Synergies	0.79	0.65
Strategic Enterprise Value	**0.57**	**0.45**

Table 7. Enterprise Value. Ranking of firms in sector X

Company	**(defuzzified) Enterprise Value**	**Valuation**
Company 1	**1.00**	**High**
Company 2	0.95	
⋮	⋮	
Company n_1	**0.80**	
Company n_1+1	0.73	**Medium High**
Company n_1+2	0.66	
⋮	⋮	
Company n_1+ n_2	**0.60**	
Company n_1+ n_2+1	0.58	**Medium Low**
Company n_1+ n_2+2	0.49	
⋮	⋮	
Company n_1+ n_2+ n_3	**0.40**	
Company n_1+ n_2+ n_3+1	0.32	**Low**
Company n_1+ n_2+ n_3+2	0.28	
⋮	⋮	
Company n	**0.00**	

This expert system is especially useful if one thinks of his application to all firms operating in the same sector. One may obtain normalized scores for the *Enterprise Value* of each firm of a particular sector which may be made publicly available to operators in the market and potential buyers. As an example, one may stipulate that firms in the interval [0-0.2) have a low value-creation power, firms in the interval [0.2-0.4) have a medium-low value-creation power, firms in the interval [0.4, 0.6) have a medium-high value-creation power and the interval [0.8-1] represents a high value-creation power. A ranking is then established among firms, analogously to a ranking of companies' bonds in different risk classes. If there are n firms in sector X, they will be divided in four groups, each of which includes n_1, n_2, n_3, n_4 firms respectively. Once fixed the 18n inputs, the expert system

computes the appropriate score for each firm, which will be inserted in the corresponding group (see Table 7).[9]

4. Sensitivity analysis: the relative weight of Enterprise Value and Synergies

Any model needs corroboration. To this end, we have tested its reliability through a series of simulations by modifying the value of one or more inputs simultaneously, while leaving the other fixed. The greater the number of simulations, the higher the degree of corroboration of the model. A sensitivity analysis has the objective to test if the final output and the intermediate variables react in a correct way to the changes of one or more input variables. The reaction has to be "correct" in terms of both correlation and magnitude (the magnitude of the reaction is particularly important for firm valuation). For reasons of space, only three simulations are described in this section[10] aimed at understanding the role of the two intermediate outputs in determining the final output and, from this point of view, test the robustness of the model.

The first simulation shows different values of the *Strategic Enterprise Value* for different values of the three determinants of *Synergies* (*Economies of Scale*, *Complementarities* and *Market Share*). The other inputs are set as in scenario 1, whereas the three determinants of *Synergies* are raised from the lowest value of 0 to the highest value of 1. Table 8 shows the value drivers' variation in the eleven different cases considered. Looking at Table 9 one may appreciate the corresponding modifications of *Enterprise Value*, *Synergies* and the final output. As one can see, there is no variation in *Enterprise Value* (which is obvious, given that the three inputs considered are not conceptually or formally related to *Enterprise Value*), which keeps at 0.47. The value of *Synergies* rises progressively from 0 to 1, as one should expect, given that the three factors describe the worst possible situation in case 1 and the best possible situation in case 11. Correspondingly, *Strategic Enterprise Value* increases from 0.31 (case 1) to 0.64 (case 11) (case 9 just corresponds to scenario 1 in Tables 4-6).

Table 8. Changing the determinants of *Synergies*

CASE	1	2	3	4	5	6	7	8	9	10	11
Complementarities	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00
Economies of Scale	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00
Market Share	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00

Table 9. Changes in the outputs

CASE	1	2	3	4	5	6	7	8	9	10	11
Enterprise Value	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
Synergies	0.00	0.12	0.21	0.29	0.38	0.50	0.62	0.71	0.79	0.88	1.00
Strategic Enterprise Value	0.31	0.34	0.37	0.40	0.43	0.48	0.51	0.54	0.57	0.60	0.64

[9] Evidently, ranking system regards the *Enterprise Value*, not the *Strategic Enterprise Value*, because *Synergies* varies depending on whom is the buyer. Therefore, the inputs are 18 for each firm.

[10] Other simulations of a different version of the model can be found in Magni, Malagoli and Mastroleo (2006), Malagoli, Magni and Mastroleo (2007).

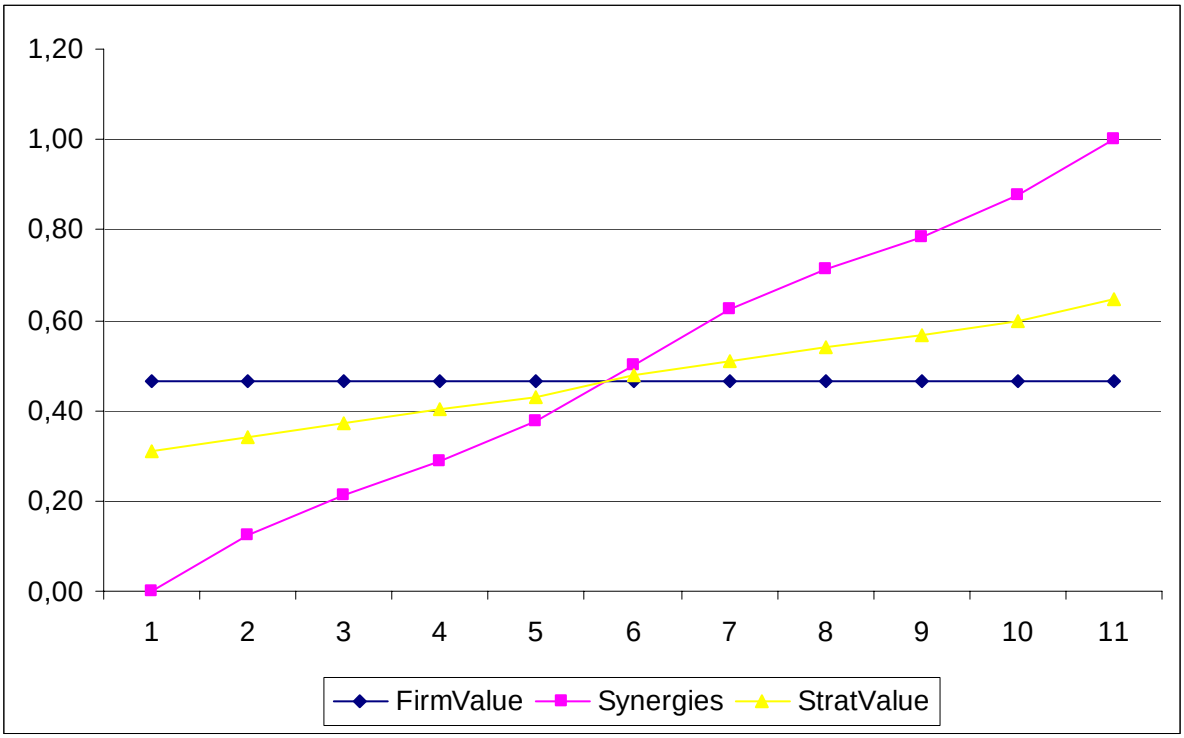

Figure 6

The first simulation confirms that the value of *Synergies* is an important element of valuation, capable of raising the final score from a medium-low value to a medium-high value. That the value of Camuzzi's *Strategic Enterprise Value* cannot be higher should be understood: *Enterprise Value* is not high enough to provide a higher final output. Figure 6 is a graphical illustration of the simulation.

To further understand the role of *Enterprise Value* and *Synergies*, we have varied the determinants of *Synergies* from 0 to 1 in two different extreme hypoteheses: (a) best possible score for each determinants of *Enterprise Value* (which takes on the maximum value of 1) (b) worst possible score for each determinant of *Enterprise Value* (which takes on the minimum value of 0).

Tables 10-11 show the result of these two simulations.

Table 10. Changing the determinants of Synergies with a maximum Enterprise Value

CASE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Enterprise Value	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Synergies	0.00	0.12	0.21	0.29	0.38	0.50	0.62	0.71	0.79	0.88	1.00
Strategic Enterprise Value	0.67	0.70	0.73	0.77	0.80	0.83	0.87	0.90	0.93	0.97	1

Table 11. Changing the determinants of Synergies with a minimum Enterprise Value

CASE	1	2	3	4	5	6	7	8	9	10	11
Enterprise Value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Synergies	0.00	0.12	0.21	0.29	0.38	0.50	0.62	0.71	0.79	0.88	1.00
Strategic Enterprise Value	0.00	0.03	0.07	0.10	0.13	0.17	0.20	0.23	0.27	0.30	0.33

It is worth noting that in all the three simulations *Synergies* affects the *Strategic Enterprise Value* by 0.33: in the first simulation the output shifts from 0.31 to 0.64, in the second simulation it rises from 0.67 to 1, in the third simulation it increases from 0 to 0.33.

This means that, given a determined score for *Enterprise Value*, *Synergies* is capable of increasing (decreasing) the *Strategic Enterprise Value* by 0.33. This informs about the relative weight of *Synergies* with respect to the final output, but also suggests a test for the robustness of the model: if the expert system is robust, then we expect that, given a relative weight of Synergies of 0.33, the relative weight of Enterprise Value should amount to about 0.67 (=1−0.33). This is actually what the system provides: given a determined score for *Synergies*, the *Enterprise Value* is capable of increasing (decreasing) the *Strategic Enterprise Value* by 0.67. To verify it, we just have to fix a value of *Synergies* and see how the final output reacts if *Enterprise Value* is increased. Just rearranging Tables 9-11 we obtain a result that confirms robustness (Table 12 reports some examples extracted from the eleven cases): increases is 0.67.

Table 12. Changes in the Enterprise Value

CASE	1	2	3	Increases
Enterprise Value	0.00	0.47	1.00	
Synergies	0.00	0.00	0.00	
Strategic Enterprise Value	0.00	0.31	0.67	0.67
Synergies	0.29	0.29	0.29	
Strategic Enterprise Value	0.10	0.4	0.77	0.67
Synergies	0.50	0.50	0.50	
Strategic Enterprise Value	0.17	0.48	0.84	0.67
Synergies	0.71	0.71	0.71	
Strategic Enterprise Value	0.23	0.54	0.90	0.67
Synergies	1.00	1.00	1.00	
Strategic Enterprise Value	0.33	0.64	1.00	0.67

5. Pricing

If a potential buyer intends to acquire the firm and needs to know the price at which the firm should be acquired, it is possible to convert the scoring provided by the expert system into a price. One of the possible methods to extract a price is to make use of regression analysis. As seen, the expert system we have constructed for this application is conceptually and technically divided into two main blocks: *Enterprise Value* and *Synergies*. It is then possible to price each block separately and then sum the two shares to obtain the price a strategic investor should pay for acquiring the assets of the target firm.

In general, the process should be composed by the following steps:

(1) Choose a subclass of firms (at least two) in the market which are regarded as fairly priced. Data should be collected on an efficient financial market (e.g. NYSE)
(2) For each of the chosen firms isolate the value drivers that actively affect *Enterprise Value*. They are: *Tax Rate, Competitive Rivalry, Sensitivity to Macroeconomic Factors, Operating Leverage, Consumer Price Sensitivity, Quality of Management, Reinvestment Rate, ROI, Acquisitions, Net Capital Expenditures, Investment in Non-Cash Working Capital, Entry Barriers, Processes Efficiency, Customer Concentration, Supplier Concentration, Capital Expenditures in R&D, Resources and Skills and Technology*. Fix the correct values for the firms at hand and compute, via expert system, the defuzzified *Enterprise Value* for each of these firms
(3) Associate to each *Enterprise Value* so obtained its Enterprise Value/Ebitda ratio and plot the pairs (x,y) on an xy-plane, where x is the (defuzzified) *Enterprise Value* provided by the system and y is the EV/Ebitda ratio of the firm
(4) Run a (linear or quadratic) regression to infer the function $y=f(x)$ connecting *Enterprise Value* and the EV/Ebitda ratio
(5) Consider the target firm, compute its (defuzzified) *Enterprise Value* and put it in the analytic expression of the function as the independent variable, so as to obtain the EV/Ebitda ratio and therefore the market value of the firm.

The crucial factor of this procedure concerns the choice of the subclass of firms. Two assumptions have to be satisfied:

(a) fairly priced firms possibly belonging to the peer group of the target should be selected
(b) there must be a correspondence between the market enterprise value of the selected firms (and so their EV/Ebitda ratios) and the score computed by the system: they should express the same value notion (see section 2).

Condition (b) implies that if the target company's *Enterprise Value* provided by the system is a *Stand-Alone Optimal* Value, then the stock price of the firms selected for the regression should already include the Expected Value of Control.

If the firm is under consideration by a strategic investor willing to realize synergies, the same statistical procedure should be applied for determining the premium to be paid for the *Synergies*. In this case the synergy premium may be computed considering the market value of

equity of some selected firms before and after acquisition. Adding the market value of synergies to the market firm one finds the market *Strategic Enterprise Value*.[11]

The problem is that it is not easy to ascertain whether and when the stock price includes (i) the value of control, (ii) the value of synergies (iii) both the value of control and the value of synergies, (iv) neither the value of control nor the value of synergies, (v) the value of control, the value of synergies, *and* an overpayment. Hostile takeovers represent a good example of the importance of control premiums, since the "hostility" of the operation often stands in the will of the buyer to replace the target firm's management team to grasp the hidden value. It is therefore necessary to find empirical evidence supportive of the fact that hostile takeovers are fundamentally motivated by control. A first distinction has to be made between hostile takeovers led by strategic investors who intend to generate synergies and hostile takeovers where the target firm remains independent after the deal, or acquisitions conducted by individual investors or acquiring entities that can't generate synergies (e.g. private equity funds, pension funds). One may state that when the buyer is not a "synergy hunter" the rationale of the operation is control and the premium paid is only a control premium (eliminating the cases of overpayment). Damodaran cites some scientific studies supportive of the evidence of a large perceived benefit from control in hostile acquisitions, positively seen by the market (Lang, Stultz, and Walkling, 1989). There are also empirical evidences consistent with the assumptions that the existence itself of a market for corporate control lies in the target firms characteristics (low operating performances and stock price performance) and that relevant managerial changes follow hostile takeovers (Bhide, 1989).

Table 13. Bidders and motives

	Control	**Synergies**
Financial Investors through MBO and MBI (Private Equity Funds, individual investors)	Yes (if majority owners)	Not often
Strategic Investors (friendly acquisitions)	Should not be paid if no managerial change follows the bid	Yes
Strategic Investors (hostile takeovers)	Yes	Yes (often)

Assuming that the regression regards the *Enterprise Value* intended as a *Stand-Alone Optimal Value*, to satisfy condition (b) above one should select firms that:

(i) belong to the peer group of the target company. The number of observations should be sufficiently wide to act as a significant statistical sample

[11] An alternative procedure is that of running a regression connecting directly the *Strategic Enterprise Value* computed by the system and the EV/Ebitda market multiple. In this case the stock price of the selected firms should incorporate not only a control premium, but also a synergy premium.

(ii) have been object of a hostile acquisition. Market data after the acquisition should be used, but values before acquisition may also be employed in a context where stock prices tend to reflect the expected value of control (high likelihood of management change);
(iii) have not been acquired for creating synergies, so that the premium paid is entirely attributable to the value of control (the target firm remains independent after the deal).

One should reject firms whose:

(iv) market value may reflect an overpayment;
(v) expected value of control is partly attributable to excess cash balances (short term investments below market rates or management misuse of the excess liquidity), or to capital structure optimization.

Point (v) depends on the fact that the definition of *Enterprise Value* adopted in our model corresponds to an *unlevered* enterprise value, with no consideration of all the aspects related to the capital structure and the cost of debt financing. Also, we have focused only on the value-creation components that affect operating assets, so neglecting non-operating assets (e.g. cash and marketable securities, holdings in other companies, pension fund assets) which are usually considered separately in the transaction processes even when a significant portion of a firm's value derive from them (separate valuation). A consequence of this fact is that care must be taken for the choice of the right numerator in the EV/Ebitda ratio: cash not regarding operating activities has to be subtracted from the market value of debt and equity.

Once converted both the *Enterprise Value* and the *Synergies* into a price, a strategic investor can determine the highest price payable for the target's assets (operating and non-operating) in the following way:

	Enterprise Value extracted through the first regression
+	Value of synergies extracted through the second regression
+	Cash and marketable securities
+	Holdings and other non-operating assets
+	Value of Tax Shield
−	Debt
	Maximum price to be paid for acquisition of the target firm's equity

6. Value drivers and intermediate variables

6.1 Value Drivers

- Acquisition. The portion of capital expenditures represented by the target firm's prospective external investments. This variable has been treated as a qualitative variable.

- Capital Expenditures in R&D *(Expenditures in R&D)*. Research and development expenses represent a capital expenditure. To determine the value of capital expenditures in research and

development one may use their average value (calculated over the last five years) as a percentage of revenues.

- **Competitive Rivalry**. The pressure determined by the rivalry among competitors inside the competitive arena. Due to the difficulties in finding a quantitative expression to the competitive rivalry, this variable is considered as a typical qualitative variable.

- **Complementarities**. We use the term complementarities to identify resources-and-skills complementarities and market complementarities, considering the diseconomies derived from any kind of overlapping and cannibalization. Even if an acquisition or a merger is viable and it makes sense in terms of complementary resources, nevertheless it can fail because of a cultural mismatch between the buyer and the target company. So, this variable expresses both the degree of complementarity and the degree of potential cultural match between the two enterprises (if the cultural match is too difficult to be taken into account, one may rely on the former only).

-Consumer Price Sensitivity (*Price Sensitivity*). A qualitative variable expressing customers' price sensitivity. It is one of the two determinants of specific risk in our model (the other one is the operating leverage).

-Customer Concentration. To measure customer concentration we use the ratio

$$\frac{\text{average sales per client}}{\text{total sales}}.$$

-Economies of Scale. This variable has a qualitative expression in the model (ranging from low to high), and represents the economies of scale that Enel is capable of exploit in acquiring Camuzzi. Like *Complementarities* this variable takes on a subjective meaning and depends on the unique match between Enel and Camuzzi.

-Entry Barriers. The entry barriers which prevent potential competitors from entering the business. It is a qualitative variable.

-Investment in Non Cash Working Capital (***NonCash Working Capital***). The third variable affecting the reinvestment needs is noncash working capital. Short term investments in inventories and accounts receivable represent a negative cash flow like any other long term investment in plant and equipment. As for the ranges of the linguistic attributes, they depend on the industry considered. We have considered the value of the last fiscal year of the firm's ratio *NonCashWC/Revenues*, compared to the industry average of the same ratio calculated on the same year.

-Management Quality. The quality of management affects strategic risk and depends on the experience of the firm's management. It is a qualitative variable ranging from zero (low) to one (high) with 0.5 being considered a medium value.

-**Market Share**. To determine the market power of the combined entity we have used Camuzzi's market share on the Italian Gas market at the time of the transaction. The reference to the Italian market – and not to the European one – depends principally from the fact that increasing power on the national market was one of the most important goals of the acquisition.

-**Net Capital Expenditures** ***(Capital Expenditures)***. It is one of the three determinants of the intermediate variable *Reinvestment needs* and includes the fair adjustments for the capitalizations of R&D and of SG&A (selling, general and administrative expenses), net of depreciations and amortizations. In order to grant more transparency to the model we do not include here the acquisitions (the latter are considered as a different value driver). The ranges of the linguistic attributes of this variable depend on the peculiarities of the different industries. To determine them, one can use the average (e.g. last three fiscal years) of the firm's ratio *NetCapExp/Revenues* compared to the industry average of the last year.

-**Operating Leverage**. The operating leverage expresses the costs' structure of the firm: the proportion of fixed costs on total costs (fixed+variable). It is a significant driver of specific risk, because a high operating leverage (high proportion of fixed costs) magnifies the effect of sales fluctuations on profit. An average over the last three fiscal years of this ratio can be used to express this variable. The ranges of the linguistic attributes of this driver (as those of all non-qualitative variables in the model) can be easily defined through a statistical calculation of the distribution of values around the industry average.

-**Processes Efficiency**. The current efficiency of Camuzzi's processes. This is a qualitative variable in the model, even though in some specific industry it is actually possible to find a quantitative measure identifying efficiency. Even if an acquisition is under examination and the processes efficiency of the target firm can be improved by the buyer, the potential improvement should not be included in the definition of this variable. This potential improvement is already considered in the model: investment in R&D (which affects product quality) and economies of scales (a determinant of synergies) are two examples of potential future improvement in efficiency.

-**Reinvestment Rate**. The reinvestment rate is defined as

$$\frac{\text{capital expenditures} - \text{depreciation} + \Delta \text{ noncash working capital.}}{\text{EBIT}*(1 - \text{tax rate})}$$

An average on the last five years can be used, if representative of a forward-looking perspective. Again, the numerical intervals for the attributes of this variable can be defined through a statistical calculation of the distribution of values around the industry average.

-**Resources and Skills**. Resources and skill owned by Camuzzi. This variable has a double correlation in the tree: it is one of the two determinants of the product quality and it is one of the three determinants of the strategic risk. It is a qualitative variable.

-**Return on Investment (ROI)**. The return on investment is equal to the ratio

$$\frac{\text{EBIT} * (1 - \text{tax rate})}{\text{capital invested}}.$$

Its value should be fixed in a forward-looking perspective (the geometric average in recent years may be meaningful).

-Sensitivity to Macroeconomic Variables (*Sensitivity to Economy*). To express the sensitivity to macroeconomic factors that affect the business risk, we have considered relevant the unlevered beta of the industry.

-Supplier Concentration. To express the supplier concentration one may use the ratio

$$\frac{\text{average purchase cost of raw materials per supplier}}{\text{total cost of raw materials' purchases}}.$$

-Tax Rate. The marginal corporate tax rate.

-Technology. The quality and degree of technology owned by Camuzzi. We have considered technology as a qualitative variable, even if in some cases and in some specific sector, some alternative measure may be used (e.g. value of patents recorded among the intangible assets).

6.2 Intermediate variables

- Bargaining Power. This variable identifies the bargaining power of the target firm towards customers
and suppliers and depends on two input variables: *Customer Concentration* and *Supplier Concentration.*

- Business Risk.. It identifies the risk of the industry in which Camuzzi operates. It is one of the three determinants of operating risk and depends on *Competitive Rivalry* and *Sensitivity to Economy.*

- Free Cash Flow to Firm (FCFF). By Free Cash Flow to Firm we mean the cash flows available to shareholders assuming that the firm is unlevered.[12] This variable is one of the three determinants of *Enterprise Value* and, in turn, depends on three drivers: two intermediate variables (the operating margin, i.e. EBIT, and the reinvestment needs), and one input variable (the tax rate).

- Growth Rate. The growth rate must be an expected growth rate (forward-looking perspective). In our model it depends on two input variables: *Reinvestment Rate* and *ROI*.

- Operating Costs. In our model the magnitude of the operating costs depends on *Processes Efficiency* and on an intermediate variable expressing the bargaining power towards suppliers and clients.

- Operating Margin. The operating margin results from a composition of three variables: *Operating Costs*, *Revenues* and *Entry Barrier*s.

- Operating Risk. We have assumed the point of view of a shareholder without a diversified portfolio, thus considering the whole operating risk (not only the systematic component). We therefore isolate three different determinants for the operating risk: strategic risk, business risk and specific risk. Instead of using the standard deviation of the operating returns as a measure of the

[12] In general, FCFF=EBIT(1−tax rate)− Δ working capital requirements − Δ Net Fixed Assets+ Debt. However, the notion we here employ excludes excess cash and marketable securities, as well as other non-core businesses. See Ruback (2002) and Fernández (2002) for relation with the notion of Capital Cash Flow.

total operating risk, we opt for the definition of some more accurate variables which could specifically identify the three risk determinants. Even though the use of a single statistical variable could simplify the model, we believe that a finer decomposition of risk drivers helps to get to a meticulous and faultless valuation. In order to stress the most specific risk determinants of the firm, in the operating risk's rule block we give a higher weight to the strategic and specific risk than to the business risk. Of course the flexibility of the system enables one to change and adapt the model to the specific case at hand (for example assuming the point of view of a diversified investor and therefore considering only the systematic component of risk).

- **Product Quality**. The three determinants of the target firm's product quality are: *Expenditures in R&D*, *Resources and Skills*, *Technology*. These inputs, all positively correlated with *Product Quality*, have been given the same relative importance (same weight).

- **Reinvestment Needs**. In order to grant the model the greatest transparency we distinguish investments in acquisitions from capital expenditures in PPE (Property, Plant and Equipment). Consequently the reinvestment needs depend on three determinants: *Net Capital Expenditures*, *Acquisition* and *NonCash Working Capital*, all in a forward-looking perspective.

- **Revenues**. *Product Quality* and *Bargaining Power* are the antecedents of the intermediate variable *Revenues*.

- **Specific Risk**. In our model the specific risk depends on two decisive factors of the firm: *Operating Leverage* and *Price Sensitivity*.

- **Strategic Risk**. The strategic risk depends on three antecedents: *Resources and Skills*, *Technology* (these two input variables affect *Product Quality* as well) and *Management Quality.*

7. Conclusions

This paper presents a fuzzy expert system aimed at rating firms. The system takes account of financial, managerial, strategic factors, either qualitative or quantitative. We have considered twenty-one inputs (value drivers), which are fuzzified and aggregated in several groups through "if-then" rule blocks in order to obtain intermediate variables. The intermediate variables are in turn combined in groups so as to give rise to other intermediate variables, and so on until two intermediate outputs are reached: *Synergies* and *Enterprise Value* (unlevered, stand-alone, status-quo, core-business). These intermediate outputs are aggregated to give rise to the *Strategic Enterprise Value*, which is defuzzified so as to provide the evaluator with a score in the interval [0,1], which represents the value-creation power of the firm.

For explanatory purposes, we have focused on a real-life case of Camuzzi a natural gas distributor, recently acquired by Enel, Italian ex monopolist of electric energy. However, the model serves various purposes: especially, it may be fruitfully employed for ranking firms operating in the same sector. Such a ranking may be used for public information and for establishing consistent market values: the higher the rank the higher the market value of the firm. Furthermore, the model may be used as a tool for assessing the value of managers' decisions (and therefore as a basis for compensation) or for comparing business units. A price may actually be extracted from the normalized rating of the firm; in this case, a considerable amount of data should be available and some regression analysis should be conducted to establish a function connecting a defuzzifed *Enterprise Value* with a market value (analogously for extracting the synergy premium). To this

end, care must be taken to the notion of value employed and explicit consideration should be taken of the value of control, the value of synergies, and the value of the tax shield, in order to avoid overcalculation.

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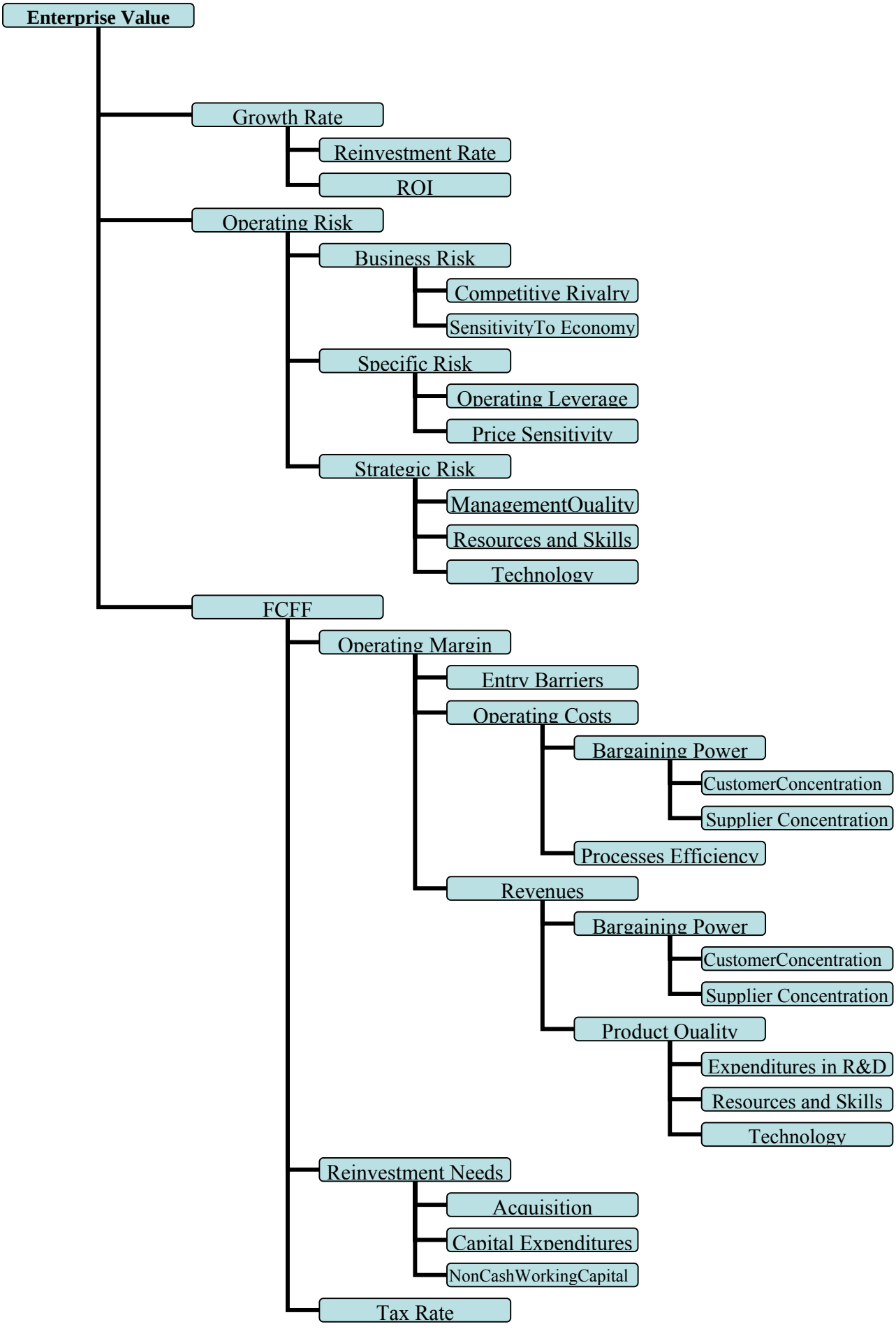
Enterprise Value
Growth Rate
Reinvestment Rate
ROI
Operating Risk
Business Risk
Competitive Rivalry
SensitivityTo Economy
Specific Risk
Operating Leverage
Price Sensitivity
Strategic Risk
ManagementQuality
Resources and Skills
Technology
FCFF
Operating Margin
Entry Barriers
Operating Costs
Bargaining Power
CustomerConcentration
Supplier Concentration
Processes Efficiency
Revenues
Bargaining Power
CustomerConcentration
Supplier Concentration
Product Quality
Expenditures in R&D
Resources and Skills
Technology
Reinvestment Needs
Acquisition
Capital Expenditures
NonCashWorkingCapital
Tax Rate