APPLYING MPCA ANALYSIS TO EVALUATE FINANCIAL PERFORMANCE OF ROMANIAN LISTED COMPANIES

Victoria Bogdan, Olimpia Iuliana Ban, Dorina Nicoleta Popa

Department of Finance-Accounting, Faculty of Economic Sciences, University of Oradea, Oradea, Romania vbogdan@uoradea.ro oban@uoradea.ro dlezeu@uoradea.ro

Abstract: The paper aims to investigate the main determinants of financial performance of Romanian companies using principal component analysis technique (PCA) for the year 2015 by constructing a composite index of financial performance and revealing also the main groups of companies according to their performance using cluster analysis technique. For this, the methodology of building composite indices proposed by the OECD (2008) will be applied. Furthermore, the sample used in the analysis covers a number of 57 companies from 8 economic sectors at the level of 2015. The analysis used 11 financial accounting indicators: market value added (MVA), added liquid value / credit valuation adjustment (CVA), weighted average cost of capital (WACC), earnings per share (EPS), price earnings ratio (PER), dividend per share (DPS), return on assets (ROA), return on equity (ROE), share of intangible assets (intangible investments) in total turnover (ITO), global solvency (SOL) and current liquidity (CL). Data was collected from the annual financial statements published on the websites of the sampled companies or through the BSE website. The empirical results of MPCA analysis revealed that the financial indicators such as return on assets, share of intangible assets (intangible investments) in total turnover, added market value and global solvency as well as current liquidity are the main determinants of financial performance of Romanian companies. Analyzing the main groups of companies according with their financial performance for the year 2015, the cluster analysis pointed out the existence of two main poles of financial performance: S.N.T.G.N. TRANSGAZ and PETROLEXPORTIMPORT, leaders in their sectors.

Keywords: *financial performance; business reporting; Romanian listed companies; indicators; cluster analysis.*

JEL classification: M41; C38; G31; L25.

1. Introduction

In recent years, the analysis of financial reporting practices of listed companies tends not only to identify the main factors that influence the quantity and quality of information disclosed in the annual reports but also to the classification of factors that determine the financial and non-financial performance of companies. Beattie, McInnes and Fearnley (2004) noted that there is a consensus that the business reporting model needs to expand to serve the changing information needs of the market and provide the information required for enhanced corporate transparency and accountability. The main objective of recent research undertaken in the area of financial reporting is to measure the degree of disclosure of different categories of

information and the correlation of measurements with the guality of reporting. In our approach we started from the comprehensive financial reporting model proposed by AICPA (1994), also known as the Jenkins report, which supported the publication of quite extensive and integrated information grouped into 8 categories: financial data, operating data, management analysis, forward-looking information, information about management and shareholders, objectives and strategy, description of business and industry structure. We also considered the main features of corporate reporting presented in the OECD Corporate Governance Principles (2004). Thus, most authors were interested in measuring the corporate reporting index or voluntary disclosure index, suggesting in the researches carried out different methods of measuring and classification of the companies analyzed according to the obtained values (Healy and Palepu, 2001; Aksu and Kosedag, 2006; Lang and Ludholm, 2000; Botosan and Plumlee, 2002; Chen et al, 2007; Cheung et al, 2010; Hassan, 2010, 2012, etc.). The objective of our analysis was to measure the financial performance of listed companies in the private sector of the Romanian economy and to recognize those companies that stand out from the perspective of the financial performance and the determinants that influence it. The measurement was made by constructing a composite financial performance index based on 11 financial indicators presented below, in the section explaining the methodology used. The indicators used to construct the composite index were determined on the basis of the information gathered manually from the financial statements of the sampled companies published in their annual reports. After computing the composite financial performance index to continue the analysis, performance clusters were created and the results were interpreted. Two relevant contributions bring our study, the determination of the composite index of financial performance for the Romanian companies listed on BVB, and the cluster analysis of companies classified according to the composite index. The conclusions and limitations of this study are outlined in the last section together with future issues to be considered in order to improve the research in the field of financial performance reporting.

2. Previous research on financial performance of listed companies

It is well known that, performance is a difficult concept, in terms of definition and measurement and as Almajali, Alamro and Al-Soub (2012) noted can been defined as the result of activity, and also, the appropriate measure selected to assess corporate performance is considered to depend on the type of the entity and the objectives to be achieved. Generally, when we consider an entity's performance, we refer to financial performance and non-financial performance. Our study relates only to financial performance. Several authors (Havnes and Senneseth 2001; Oerlemans et al. 2001: Hagedoorn and Cloodt 2003: Knobena and Oerlemans, 2006) believe that financial performance is often expressed in terms of growth of sales, turnover, employment, or stock prices, whereas innovative performance is generally expressed in terms of expenditures, patents, percentage of innovative sales, or selfreported innovations. In terms of financial performance measurement methods there are known various ways of evaluation and different ratios are used depending on the objectives that are pursuit. Traditionally, the most widely used ratios are turnover, total assets, average number of employees and net profit. In Almajali, Alamro and Al-Soub (2012) opinion, the primary ratios used for analyzing the performance of a company can be categorized into five groups: liquidity ratios, asset management

ratios, debt management ratios, profitability ratios and market value ratios. Another classification of the indicators used to measure the financial performance is proposed by Yalcin, Bayrakdaroglu and Kahraman (2012), as a mixture of traditional and modern financial ratios that are known to be as AFP (accounting financial performance) measures and VFP (value based financial performance) measures. In their study concerning the application of fuzzy multi-criteria decision making methods for financial performance evaluation of Turkish manufacturing industries, Yalcin, Bayrakdaroglu and Kahraman (2012), used four traditional measures of financial performance as, return on assets (ROA), return on equity (ROE), earning per share (EPS) and price/earnings ratio (P/E) and also, four modern measures of financial performance: Added (EVA), Market Value Added (MVA), Cash Flow Return on Investment (CFROI) and Cash Value Added (CVA). Using MCDM (Multi-criteria decision making) and FAHP (fuzzy analytic hierarchy process) Yalcin, Bayrakdaroglu and Kahraman (2012) built a hierarchical financial performance evaluation model based on the AFP and VFP main-criteria and their sub-criteria and are ranked the companies according to their own manufacturing sector by using TOPSIS and VIKOR comparatively. According to the ranking obtained results, the best company is the same with regard to both methods in five Turkish investigated sectors (Yalcin, Bayrakdaroglu and Kahraman, 2012). Using DEA (data envelopment analysis), in order to determine a multi-factor financial performance model which recognizes trade-offs among various financial measures, Zhu (2000), investigated the multidimensional financial performance of the Fortune 500 companies, and found that revenue-top-ranked companies do not necessarily have top-ranked performance in terms of profitability and (stock) marketability. DaSilva and Leal (2005) conducting a panel data analysis explored the relationship between the quality of a firm's corporate governance practices and its valuation and performance through the construction of a broad firm-specific corporate governance index for Brazilian listed companies. DaSilva and Leal (2005)'s results showed that less than 4% of Brazilian firms present "good" corporate governance practices and that firms with better corporate governance have significantly higher performance (measured through, return on assets). Abdullah and Ismail (2008) examined the extent of voluntary accounting ratio disclosures in corporate annual reports of Malaysian listed companies, analyzing for each sampled company the disclosure of the following ratios: profitability, investment, liquidity, leverage and efficiency. Results of Abdullah and Ismail (2008)'s study showed that on average Malaysian listed companies disclose between 3 to 4 types of accounting ratios and the highest number of ratios disclosed is 14 and as a conclusion is observed that there is a lack of effort and interest in using financial ratios to explain their financial results in their corporate annual reports. As regard the studies conducted by Romanian authors investigating the performance and reporting disclosure practices of Romanian listed companies we observed that most of them are interested in analyzing transparency and disclosure through annual reports and its relevance for companies' performance in the context of IFRS implementation (Fekete, Tiron Tudor, Mutiu, 2009; Tiron Tudor, 2006; Ionascu & Ionascu, 2012; Mironiuc, Carp, Chersan, 2015; Neag, 2014). Only a few studies are oriented towards the investigation and analysis of main determinants of Romanian companies' financial performance (Pantea, Gligor, Anis, 2014; Burca and Batrinca, 2014; Filip and Raffournier, 2010). Taken into account previous studies conducted on financial performance and accounting ratios we have built our own group of selected accounting ratios based upon the tradition of

The Annals of the University of Oradea. Economic Sciences, Tom XXVI 2017, Issue 1 🖽

Romanian companies in the use of indicators that measure, interpret and analyze financial performance.

· · ·	ie ne. i celebied and proposed interioral performance ratios					
	Measurement indicators of financial	Selected and used				
	performance	financial ratios				
	1. profitability ratios	EPS, DPS				
	2. value added and market ratios	WACC, MVA, CVA, PER				
	5. other financial ratios	ROA, ROE, ITO, SOL, CL				

Table no. 1 Selected and proposed financial performance ratios

Source: own proposal

3. Data and methodology

The purpose of this paper is to identify the determinants of the performance of the companies in the sample considered in the analysis based on the financialaccounting indicators gathered from the financial statements, building a synthetic performance index of the companies and highlighting the most important classes of companies according to their performances. For this, the company's composite performance index will be determined on the basis of the relevant financialaccounting indicators registered in 2015 using the principal component analysis and highlighting the main classes of companies according to performance will be carried out on the basis of cluster analysis. The usefulness of the composite index lies in the fact that it aggregates several individual indicators to provide a synthetic measure (a summary statistic) of a complex, multidimensional, and significant subject. Since most of the time the variables included in the analysis have different units of measurement and they will be combined in a synthetic indicator, in constructing the composite index, standardization is one of the fundamental operations, which involves the transformation of the variables into scores z bringing the indicators on a common scale with average 0 and standard deviation 1. The principal component analysis is a technique that involves reducing the larger number of indicators of a set of data into a smaller set of uncorrelated factors (main components) to recover as much as possible of the variation of the original variables, so that the loss of information is minimal. The purpose of the analysis is to reduce the data set by identifying the main components uncorrelated between them that should recover as much as possible from the original variables. Once the main components that capture the latent hidden information in the set of initial indices are identified, the construction of the composite index takes into account the weights obtained from the principal component analysis, using the proportion of the recovered variant of each main component in the total of recovered variant as the weights of the scores of factors to determine the non-standardized index. To facilitate the interpretation, the composite index will be scaled to take values between 0 and 100, where the highest performing company takes value 100, and at the opposite end the less performing company takes 0. Once identified the determinants of the performance of the sampled companies in 2015, the cluster analysis leads to the classification of the companies based on relevant indicators in a much smaller number of homogeneous classes so that the entities belonging to the same class are more similar to each other by the values of their variables (that is, to be similar) while the constituent classes are as different as possible. In the analysis, at the level of 2015, it will be considered a sample of 57 companies from 8 economic sectors using 11 financial-

accounting indicators: market value added (MVA), added liquid value / credit valuation adjustment (CVA), weighted average cost of capital (WACC), earnings per share (EPS), price earnings ratio (PER), dividend per share (DPS), return on assets (ROA), return on equity (ROE), share of intangible assets (intangible investments) in total turnover (ITO), global solvency (SOL), current liquidity (CL). The data was collected from the annual financial statements published on the websites of the sampled companies or through the BSE website. In order to identify the most important factors for assessing the performances of the companies in the considered sample, it will be taken into account the problem of the different measurement units of the 11 financial indicators on the basis of which this index will be constructed, so it is necessary to apply a data normalization technique. The company performance index has been achieved with the use of the statistical software SPSS 24.

4. Discussion of results

The empirical results of the principal component analysis highlight the existence of four main components, extracted using the Kaiser criterion, which stipulates the choice of the main components above or very close to the value 1, which recovers a total of 82% of the variant of the original variables.

Initial Eigenvalues			Extraction Sums of Squared Loadings		Rotation Sums of Squared Loadings				
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.849	34.992	34.992	3.849	34.992	34.992	3.649	33.174	33.174
2	2.391	21.736	56.728	2.391	21.736	56.728	2.450	22.277	55.450
3	1.637	14.884	71.611	1.637	14.884	71.611	1.705	15.501	70.951
4	1.144	10.396	82.007	1.144	10.396	82.007	1.216	11.056	82.007
5	.982	8.924	90.931						
6	.351	3.190	94.121						
7	.260	2.363	96.484						
8	.233	2.117	98.601						
9	.131	1.187	99.788						
10	.022	.204	99.992						
11	.001	.008	100.000						

Table no. 2 PCA's Own Values and Own Vectors Total Variance Explained

Extraction Method: Principal Component Analysis

Source: own processing of the data

Analyzing the results from Table 2, we can say that the first component λ 1= 3,849 explains approximately 34,99% of the original data version, while the second component λ_2 = 2,391 recovers 21,736% of the total version, totalling together 56,72%. The third component λ_3 =1,637 recovers a total of 14,88% of the total version while the fourth component $\lambda_1 = 1,144$ adds more than 10,39% of the original indicators. For the interpretation of the main components in terms of the original indicators, we will analyze the correlation coefficients calculated between the two main components and the main financial variables so that a main component can be

The Annals of the University of Oradea. Economic Sciences, Tom XXVI 2017, Issue 1 🖽

interpreted by the initial variable for which the correlation coefficient is maximum but, at the same time, the initial variable has low correlation coefficients with the other main components. To facilitate the interpretation, it is recommended to rotate the axes using the Varimax technique to obtain the lowest correlation coefficients on one or two main components.

Table no. 3 Rotated Main Component Matrix Rotated Component Matrix^a

	Component			
	1	2	3	4
Zscore: Valoarea de piață adăugată (MVA)	067	.005	.088	.943
Zscore: Valoarea lichidă adăugată (CVA)	093	793	080	462
Zscore: Costul Mediu al Capitalului (CMPC)	.978	.063	.046	.050
Zscore: Rezultat net pe acțiune (EPS)	.974	.144	.011	.007
Zscore: Coeficient de capitalizare bursieră (PER)	072	.043	.279	240
Zscore: Dividend pe acțiune (DPS)	.042	.942	.100	048
Zscore: Rentabilitatea activelor (ROA)	.977	.065	.060	.050
Zscore: Rata rentabilității financiare (ROE)	857	.074	108	.086
Zscore: Ponderea activelor necorporale (investițiilor nemateriale) în total cifra de afaceri (ITO)	.040	.939	025	175
Zscore: Solvabilitatea globală (SOL)	.152	042	.899	.069
Zscore: Lichiditate curentă (CR)	.097	.119	.881	.079

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

Rotation converged in 5 iterations.

Source: own processing of the data

Analyzing the correlation coefficients closest to the +1 or -1 values, we can state that the first main component can be interpreted in terms of return on assets ROA (0,977), Weighted Average Cost of Capital (0,978) or earnings per share (0,974). The second component is strongly correlated with the dividend per share (0,942) and the share of intangible assets (intangible investments) in total turnover (ITO) (0,939). The third factor is dominated by variables such as global solvency (0,899) and current liquidity (0,881). The last component is interpreted in terms of market value added MVA (0,943). To evaluate the quality of the results obtained by the PCA analysis, the tests KMO and Bartlett's test of sphericity have been applied. KMO

measures the sample's suitability and must exceed the threshold of 0,5 for a satisfactory analysis to be achieved. In our case, the KMO value exceeds this threshold, so we can assume that the analysis may be appropriate. Also, the Bartlett test is statistically significant, the associated probability being less than 0,05 (Approx Chi-Sq=589,711).

Table no. 4 Results of KMO and Bartlett's Test

Kaiser-Meyer-Olkin Mea	.695	
Bartlett's Test of	Approx. Chi-Square	589.711
Sphericity	df	55
	Sig.	.000

KMO and Bartlett's Test

Source: own processing of the data



Figure no. 1. Financial Performance Index of Sampled Companies in 2015 Source: own processing of the data

For the construction of the composite index we take into account the proportion recovered by each main component in the total of the initial factors version. Thus, the company's financial performance index is determined as follows:

$$Fin_perf_index = \frac{34.99}{82.00} \cdot PC1 + \frac{21.73}{82.00} \cdot PC2 + \frac{14.88}{82.00} \cdot PC3 + \frac{10.89}{82.00} \cdot PC4$$

This index is scaled later to take values between 0 (lowest performance level) and 100 (highest performance level) using the percentile rank. A value of 50 is average performance. Analyzing the performance of companies in the sample at the level of 2015, it can be seen that the companies with the highest level of performance are Conted, Prodplast, Conpet, Transgaz and Socep.

Considering that the first two main components recover more than half (56,72%) of the original variables, classifying the companies according to these the following classes of companies are highlighted:

- the first class made of PETROLEXPORTIMPORT S.A. with poor scores on both components;
- the second class made of the company S.N.T.G.N. TRANSGAZ S.A. with good scores on both components;
- and the rest of the low-scoring companies on the first component and a poor • score on the second component.



Figure no. 2 Distribution of companies in the space of the two main components (Return on assets and share of intangible assets (intangible investments) in total turnover)

Source: own processing of the data

The Annals of the University of Oradea. Economic Sciences, Tom XXVI 2017, Issue 1 🖽

By completing this analysis, taking into account this time all four main components, we will perform the classification of companies according to the performance in 2015 using the cluster analysis. The analysis assumes that each company is created in one class and then the most similar two classes group together resulting in a cluster that contains both companies. The criterion behind this analysis is the distance. In the cluster analysis we used the Euclidean square distance and the classification method based on the centroid method. The empirical results of the dendrogram revealed the existence of three classes of companies:

- class 1 formed of PETROLEXPORTIMPORT S.A;
- class 2 formed of S.N.T.G.N. TRANSGAZ;
- the rest of the companies.

Analyzing the results comparatively, it can be argued that the two companies, PETROLEXPORTIMPORT S.A and S.N.T.G.N. TRANSGAZ, represent financial performance poles at the level of 2015 year in areas such as wholesale and retail, and transportation and warehousing.





The Annals of the University of Oradea. Economic Sciences, Tom XXVI 2017, Issue 1 🖽

5. Conclusion, limits and further research

This study focused on the analysis of financial performance of Romanian sampled listed companies with the help of building the composite financial performance index. Also, the paper aimed at identifying the most relevant factors of the company's financial performance and classifying the companies from eight economic sectors according to their performance in the year 2015, using the principal component analysis and cluster analysis as well as multidimensional data analysis techniques. The empirical results have highlighted return on assets (ROA), share of intangible assets in total turnover (ITO), added market value (MVA) and global solvency (SOL) as well as current liquidity (CL) as the key determinants of the financial performance of investigated Romanian listed companies. The results of the cluster analysis revealed that there are two poles of financial performance at the level of 2015, S.N.T.G.N. TRANSGAZ and PETROLEXPORTIMPORT, leaders in their sectors. As regard the limits of the study, these are mainly found in the formation of the sampled analyzed companies and the selection of the indicators for building the composite index of financial performance. Future research will pursue the identification and application of modern methods in order to evaluate financial and non-financial performance of listed companies, and the investigation of the existing correlations between reporting disclosure indexes, performance and several disclosed accounting variables.

References

1. Abdullah, A., Ismail, K.N.I.K. (2008) "Disclosure of Voluntary Accounting Ratios by Malaysian Listed Companies", *Journal of Financial Reporting & Accounting*, 6, n0. 1, 1-20.

2. AICPA, (1994) "Improving Business Reporting – A Customer Focus: Meeting the Information Needs of Investors and Creditors, Comprehensive Report of the Special Committee on Financial Reporting (The Jenkins Report)", New York, NY: American Institute of Certified Public Accountants.

3. Aksu, M., Kosedag, A. (2006) "Transparency and disclosure scores and their determinants in the Istanbul Stock Exchange", Corporate Governance: An International Review, vol. 14, no. 4, 277-296.

4. Almajali, A.Y., Alamro, S.A., Al-Soub, Y.Z. (2012) "Factors affecting the financial performance of Jordanian insurance companies listed at Amman Stock Exchange", Journal of Management Research, vol. 4, no. 2. 266-289.

5. Beattie, V., McInnes, W., Fearnley, S. (2004) "A methodology for analyzing and evaluating narratives in annual reports: a comprehensive descriptive profile and metrics for disclosure quality attributes", Accounting Forum, vol. 28, no. 3, 205-236. 6. Botosan, C.A., Plumlee, M.A. (2002) "A reexamination of disclosure level and the expected cost of equity capital", Journal of Accounting Research, 40, 1, march, 21-40.

7. Burca, A.M., Batrinca, Gh. (2014) "The determinants of financial performance in the Romanian insurance market", International Journal of Academic Research in Accounting, Finance and Management Sciences, vol. 4, no. 1, 299-308.

8. Chen, A., Kao, L., Tsao, M., Wu, C. (2007) "Building a corporate governance index from the perspectives of ownership and leadership for firms in Taiwan", Corporate Governance: An International Review, vol. 15, no. 2, 251-261.

9. Cheung, Y., Jiang, P., Tan, W. (2010) "A transparency disclosure index measuring disclosures: Chinese listed companies", Journal of Accounting & Public Policy, vol. 29, no. 3, 259-280.

10. DaSilva, A.L.C., Leal, R.P.C. (2005) "Corporate Governance Index, Firm Valuation and Performance in Brazil", Revista Brasileira de Financas, vol. 3, no.1, 1-18.

11. Fekete, Sz., Tiron Tudor, A., Mutiu, A. (2009) "Determinants of the Comprehensiveness of Corporate Internet Reporting by Romanian Listed Companies", online at http://ssrn.com/abstract=1517665

12. Filip, A., Raffournier, B. (2010) "The value relevance of earnings in a transition economy: the case of Romania", The International Journal of Accounting, 45, 77-103.

13. Hagedorn, J., Cloodt, M. (2003) "Measuring innovative performance: is there an advantage in using multiple indicators?", Research Policy, 32, no. 8, 1365-1379.

14. Hassan, M.K. (2009) "The UAE corporations specific characteristics and level of risk disclosure", Managerial Auditing Journal, vol. 24, no. 7, 668-687.

15. Hassan, M.K. (2012) "A disclosure index to measure the extent of corporate governance reporting by UAE listed corporations", Journal of Financial Reporting and Accounting, vol. 10, issue 1, 4-33.

16. Havnes, P., Senneseth, K. (2001) "A panel study of firm growth among SMEs in networks", Small business economics, 293-302 in Knobena and Oerlemans (2006).

17. Healy, P. M., Palepu, K. G. (2001) "Information asymmetry, corporate disclosure, and the capital market: a review of the empirical disclosure literature, Journal of Accounting and Economics, 31, 1-3, September, 405-440.

18. Ionascu, M., Ionascu I. (2012) "The use of accounting information by financial analysts in emergent markets: the case of Romania, Proceedings of the 7th International Conference Accounting and Management Information Systems, ISSN 2247-6245, 18-28.

19. Knobena, J., Oerlemans, L.A. (2006) "The effect of firm relocation on firm performance", Regional Studies, 3.

20. Lang, M., Lundholm, R. (2000) "Voluntary disclosure and equity offerings: reducing information asymmetry or hyping the stock", Contemporary Accounting Research, 17, no. 4, 623-669.

21. Mironiuc, M., Carp, M., Chersan, I.C. (2015) "The relevance of financial reporting on the performance of quoted Romanian companies in the context of adopting the IFRS", Procedia Economics and Finance, 20, 404-413.

22. Neag, R. (2014) "The effects of IFRS on net income and equity: evidence from Romanian listed companies", Procedia Economics and Finance, 15, 1787-1790.

23. OECD, (2004) "Principles of Corporate Governance, Organization for Economic Co-operation and Development", OECD, Paris.

24. OECD, (2008) "Handbook on Constructing Composite Indicators – Methodology and user guide", online at: https://www.oecd.org/std/42495745.pdf

25. Oerlemans, L.A.G., Meeus, M.T.H. (2005) "Do organizational and spatial proximity impact of firm performance?", Regional Studies, 39, no. 1, 89-104.

26. Pantea, M., Gligor, D., Anis, C. (2014) "Economic determinants of Romanian firms' financial performance", Procedia – Social and Behavioral Sciences, 124, 272-281.

27. Tiron Tudor, A. (2006) "Disclosure and transparency of Romanian listed companies", online at

http://s3.amazonaws.com/academia.edu.documents/41311760/SSRNid920580.pdf?AWSAccessKeyId=AKIAIWOWYYGZ2Y53UL3A&Expires=14926978 77&Signature=8ulqGfvE25%2BMKLas26e1FZ%2BXcdI%3D&response-contentdisposition=inline%3B%20filename%3DDisclosure_and_transparency_of_Romani an.pdf

28. Yalcin, N., Bayrakdaroglu, A., Kahraman, C. (2012) "Application of fuzzy multicriteria decision making methods for financial performance evaluation of Turkish manufacturing industries", Expert Systems with Application, 39, 350-364.

29. Zhu, J. (2000) "Multi-factor performance measure model with an application to Fortune 500 companies", European Journal of Operational Research, 123, 105-124.