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VÍTOR DA CONCEIÇÃO GONÇALVES
ANTÓNIO PALMA DOS REIS
JOÃO DUQUE

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DEPARTAMENTO DE GESTÃO

R. Miguel Lupi, 20 – 1249-078 Lisboa – Fax: 21.392.28.08 – Telf. 21.392.28.12/23

NEURAL NETWORKS VERSUS MULTIPLE REGRESSION: CAN THEY EXPLAIN STRATEGIC PERFORMANCE?

Vítor F. C. Gonçalves[1], António Palma-dos-Reis[2] and João Duque[3]

Abstract

This paper evaluates how effective are neural networks versus multiple regression on identifying the economic and financial variables that determine the goodness of the corporate strategic choices and releases the results obtained on the evaluation of strategies. As research sample, we used the strategic decisions taken by the Portuguese financial services industry (banks and insurance companies). Based on the data collected by a questionnaire that was sent to all of the Portuguese financial firms, we were able to run several linear regressions, as well as neural networks, towards justifying firms performance based on their strategic choices, which were decomposed into four dimensions: technology adoption, strategic alliances, geographic based strategies and attention focused on competitive aspects. Even though the relevance of the four strategic dimensions was observable through linear regression analysis, neural networks always provided an R-square several points above the equivalent multiple linear regression.

Key words: Neural networks, statistical methods, multiple regression, strategic performance, financial services, banking industry, insurance, Portugal

1. Introduction

This paper aims to ascertain whether the more recent neural networks can offer a better adjustment than multiple linear regressions on evaluating the performance of the strategic choices undertaken by financial firms. This was carried out comparing the strategic decisions taken by the Portuguese financial services industry (banks and insurance companies) with their performance towards finding a pattern of the relationship between strategic choices and performance.

[1] Full Professor, ISEG - Instituto Superior de Economia e Gestão, Universidade Técnica de Lisboa
[2] Assistant Professor, ISEG - Instituto Superior de Economia e Gestão, Universidade Técnica de Lisboa
[3] Associate Professor, ISEG - Instituto Superior de Economia e Gestão, Universidade Técnica de Lisboa

In order to address these issues, we review the literature on strategic performance analysis in section 2. Afterwards, we present the variables selected and the data collection process in section 3, the data analysis methodologies and their results in section 4, and the discussion comparing the performance of the data analysis methodologies in section 5. The conclusions are presented in section 6.

2. Considerations on Strategic Decisions, Business Environment and Performance

In the literature, we find two main causes for different levels of strategic performance: the business environment and the strategic decisions. Although the environment may itself push firms' performance independently from its government process, the managerial process governing corporations should result on strategic decisions leading to an increasing performance. This dependence link has been suggested and empirically supported by Miller and Friesen [1983] and by Venkatraman and Prescott [1990] for large-scale economies of developed countries or developing countries in centrally planned economies. We have no preemptive reason to suspect that small economies will react differently and, therefore, it is reasonable to expect profitability and growth as a result of both business environment and strategic decisions. Kotha and Nair [1995] also found that, for the Japanese machine tool industry, both environment and strategic decisions seem to play significant roles on the firms' performance. However, some authors (see Grinyer et al. [1980]) seem to find the environment as a stronger explanatory variable for firms' performance. In terms of strategic decisions, several strategies can be implemented in order to obtain better results towards shareholders wealth.

We classified the firms' strategies according to Gonçalves et al. [1999] dimensions of: technological development, strategic alliances, geographic based strategies and the perceptions about competitive aspects. These dimensions are widely supported in the literature.

The relevance of technology adoption is supported by More [1987], Lusch, Zizzo and Kenderdine [1993], Kotha and Nair [1995], Raymond et al. [1996], and MacPherson [1994]. Besides, as financial services are becoming increasingly dependent on technology and as theoretical models and empirical results show, we should expect technology to have a positive impact on the financial industry performance.

The development of strategic alliances is another strategic move to face shareholders demand for wealth growth. This is supported by Luo [1996], Reijnders and Verhallen [1996], Glaister [1996], Harrigan [1988], Parkhe [1993], and Gray and Yan [1992].

Geographic-based strategies may also have a significant impact on performance. The relevance of geographic-based strategies, such as expansion to other countries or other continents, is supported by Hitt et al. [1994], as well as by Tandy and Stovel [1989].

We also found in the literature the attention given to competitive aspects as a variable justifying performance. This theoretical framework relies on the assumption that a more competitive orientation perspective will lead firms for developing more effective detection systems of environmental changes, for inducing product development or quality oriented decision making. Such an effort will guide firms to increase performance. This model, although naïve, according to Barnett et al. [1994], seems plausible in interpreting, for instance, the positive performance of Peruvian firms or when used by Oral and Singer [1992] for modeling decision support systems for strategic choices.

In summary, we found theoretical support for performance explanation based on favorable business environment conditions and on appropriate strategic decisions. We selected both aspects as possible explanations for performance and segmented strategy into 4 dimensions: technology adoption, strategic alliances, geographic based strategies and attention focused on competitive aspects. We than posit that technology adoption, strategic alliances, geographical expansion and focus on competing aspects are related to performance, as summarized by the following equation:

$$\text{Performance} = f\begin{pmatrix} \text{Business Environment;} \\ \text{Technology Adoption;} \\ \text{Strategic Alliances;} \\ \text{Geographic Based Decisions;} \\ \text{Competitive Aspects.} \end{pmatrix} \quad (1)$$

The analysis of the impact of corporate strategic choices on corporate performance is not a straight and simple task. The analysis can differ according to the perspective of the researcher and the interest that is stressed. Hence, we can focus on the shareholders wealth perspective, on the management interest perspective, or on the remaining stakeholders' point of view. Such diversity well established in the literature after the seminal paper of Jensen and Meckling [1976] on the agency theory can result on different conclusions. The criteria used to access corporate performance depend on the analysts' perspective. In this paper, the corporate performance is evaluated considering the shareholders wealth perspective.

Considering the shareholders' perspective, market or public data can be used to access performance of strategic decisions. Chakravarthy[1986], Mehra [1996] and Banker, Chang and Majundar [1996] use accounting and market data to evaluate performance of strategic decisions on the computer industry, telecommunications industry and banking industry, all in the US. In such process, Schmid [1987], Schmidt [1992] and Banker, Chang and Majundar [1996] support benchmarking as a way of comparing companies' performance.

Simple measures of performance, like the return on investment (ROI), although simple to compute and extensively used, have some shortcomings that a deeper analysis should overcome (Doyle [1994]; Krasts [1981]; Norburn and Miller [1981]). A deeper analysis could include subjective measures, as described by Dess and Robinson [1984] and Chakravarthy [1986] or performance evaluation time-based measures as suggested by Stalk and Hout [1990] and Spanner, Nuno and Chandra [1993].

Research on corporate strategic performance should be preferably based on different data sources whenever available (Burchman and Schneier [1989]). However, when financial markets are not sufficiently established and internal information data is not available, research has frequently overcame such deficit by using partial data, extending cross analysis and improving sampling significance.

3. Variable Definition and Data Collection

In order to compare the performance of these companies with their strategic choices, we used two methodologies: (1) based on the theoretical model expressed by equation 1, we applied a regression analysis procedure to study in detail whether the strategic decisions and the business environment would have an impact on the performance variables, and; (2) we built and trained a neural network to forecast performance given the firms' strategic decisions. Since both the linear regressions and the neural networks require the definition of the independent and dependent variables, we proceed to the identification of such variables.

Identifying the independent variables

We started by defining seven independent variables extracted from the questionnaires and used them as a proxy for the effort and attention given to the strategic vectors identified by Gonçalves and Grigsby [1997]. As the questionnaire was composed by a series of one hundred and six questions, which were constructed on a five-point Likert scale basis, these seven independent summary variables are the result of averaging the corresponding scores of each group of answers (Gonçalves and Grigsby, 1997). These variables, which are referred along the text as *score variables*, are defined as:

1. **TA** (Technological Adoption) – includes the adoption of communication technologies, decision support systems, multimedia systems, end-user supports, and system design and implementation methodologies.

2. **CS_SA** (Competitive Strategy; Strategic Alliances) – includes acquisitions and controlling interest over another company, joint ventures with companies in or outside of the industry, licensing arrangements, arrangements to market products or services jointly with another company, joint research and development with other companies.

3. **CS_GS** (Competitive Strategy; Geographic Strategies) – includes alternative business expansion strategies based on geographic growth.

4. **CA_S** (Competitive Aspects that a firm Should consider) – includes the cost of operations, the volume of business, the market share, the speed of operations, the ability to compete on price, the personalized service, the customer satisfaction, the wide range of products and services, the uniqueness of products and services, the investment in new product development, the technological know-how, the commercial or competitive know-how, the geographic coverage, the market segment coverage and the investment leverage.

5. **CA_A** (Competitive Aspects that a firm Actually considers) – includes the same items referred for CA_S but actually considered by firms as competitive aspects.

6. **BE_P** (Business Environment that exist at the Present time in the sector) – concerns the level of a set of factors that can help to define the business environment, such as the number of firms competing, the degree of concentration, the competitive pressure from domestic firms, the competitive pressure from foreign firms, the government regulations, the power of customers, the power of suppliers, the substitutes for products or services, the technological change and the existing barriers to entry the business.

7. **BE_I** (Business Environment is actually Increasing or decreasing in the sector) – checks whether the items mentioned for variable BE_P are actually increasing or decreasing.

Identifying the dependent variables

In order to develop the dependent variables, we selected a number of accounting variables as corporate performance indicators. This methodology was used in other studies with similar concerns such as in Chakravarthy [1986], Mehra [1996] and Banker, Chang and Majundar [1996]. The accounting variables chosen were Earnings, Total Assets and Total Sales. Although these variables were not directly used to measure the strategic performance of the companies, they were used to produce some relative measures (ratios). The accounting variables chosen were presented by Chakravarthy [1986] as conventional measures of strategic performance based on a survey of strategic performance measures. According to Woo and Willard (refered by Chakravarthy [1986]), despite some important limitations, these accounting aggregates are important instruments for performance analysis. According to Mehra [1996], accounting ratios can be used to perceive the profitability aspect of strategic performance. We think that this is acceptable, and particularly valid, when average ratios or average growth rates are used as a proxy for strategic performance analysis. When large time periods are used, fundamental analysis can provide a good approximation of market returns, as suggested, among others, by Beaver, Kettler and Scholes [1970]. For a detailed review of the literature on this subject see Elton and Gruber [1995].

Alternatively, market values could be selected for performance evaluation, but the limited number of quoted companies in 1995 in the country wouldn't recommend the use of market values. As the performance variables are average long term growth rates extracted from accounting statements and since there is a strong association in the long run between accounting based measures of returns and market based returns (Beaver, Kettler and Scholes [1970]) we restricted the analysis to the accounting measures due to the limited availability of data.

So, the variables previously identified were then used to calculate some performance indicators, in terms of the total assets used to generate the income, and in terms of the sales generating returns.

The ratios and rates computed were the following:

1. Average Return on Turnover (AROT),

$$AROT_K = \frac{1}{N}\sum_{i=1}^{N}\left[\frac{E_{K,i}}{T_{K,i}}\right] \qquad i = 1989, 1990, \ldots, 1994 \qquad (2)$$

Where $AROT_K$ is the average return on total turnover of firm K, E_{Ki} are the total earnings of firm K in year i and T_{Ki} is the total turnover of firm K in year i.

2. Average Growth Rate of Turnover (AGRT),

$$AGRT_K = \frac{1}{N}\sum_{i=1}^{N}\left[\frac{T_{K,i}}{T_{K,i-1}} - 1\right] \qquad i = 1990, \ldots, 1994 \qquad (3)$$

Where $AGRT_K$ is the average growth rate of turnover of firm K;

3. Average Return on Assets (AROA)

$$AROA_K = \frac{1}{N}\sum_{i=1}^{N}\left[\frac{E_{K,i}}{TA_{K,i}}\right] \qquad i = 1989, 1990, \ldots, 1994 \qquad (4)$$

Where $AROA_K$ is the average return on assets of firm K and TA_{Ki} are the total assets of firm K in year i.

The group of variables identified as dependent variables, due to its nature, is referred along the text as *performance variables*.

The data collection procedure

The data was collected by administering a questionnaire[4] to all banks and insurance companies based, or in activity, in Portugal as of December 1995. A follow up of the

[4] To obtain the questionnaire, please write to:
Corresponding author name and address.

questionnaire, in February of 1996, improved the rate of success, measured in terms of the number of answers to the questionnaire. From a total of 118 questionnaires sent (73 to insurance companies and 45 to banks) we got 18 answers from insurance companies and 14 from banks. Although the number of returned questionnaires was moderate, this sample represents 40% of the total Portuguese insurance industry and 60% of the total Portuguese banking industry. Table 1 expresses the Total Assets and Total Turnover for the sample and for each of the industries. Table 1 shows that the Portuguese banking industry is clearly larger than the Portuguese insurance industry. Since the sample is more representative for the former than for the latter industry, in aggregated terms, we have got a coverage rate of almost 60% of the target industries.

[Insert Table 1]

4. Searching for the relationship between score and performance variables

The search for relationships between score and performance variables was carried out computing the Pearson Correlation Coefficients, running multiple linear regressions and creating and training a neural network.

A preliminary analysis using the Pearson Correlation Coefficient

With the *performance variables* and the *score variables* defined, we proceeded to the computation of the Pearson Correlation Coefficient, presented in Table 2, in order to get a perception about possible linear correlations among variables.

[Insert Table 2]

Table 2 revealed only one correlation between score and performance variables significant at the 0,05 level, the correlation between geographical expansion strategies (CS_GS) and the average return on turnover (AROT). At the 0,1 level of significance, we can find the correlations between CS_GS and the average return on assets (AROA), the attention actually given to competitive aspects (CA_A) and the average return on assets (AROA), and between the perception of increasing competitiveness in the business environment (BE_I) and the average return on turnover (AROT). No score variable revealed a significant correlation coefficient with the average growth rate of turnover (AGRT).

The lack of significant correlation coefficients indicates that we cannot expect to find linear one-to-one relationships between score and performance variables. However, the Pearson Correlation Coefficient is not suitable for evaluating either relationships combining more than one score variable or non-linear relationships.

So, we proceed to the stepwise linear regressions, an approach that, although following the linear model, combines the effect of multiple score variables into the explanation of the performance variable.

Linear Regression Analysis

The following linear regressions test the expectations based on the literature review that performance is related with strategic choices. We hypothesized, as suggested by Nichols, Dwyer and Sann [1996], that firms' performance should be the result of the effort given to the strategic variables selected. As explained earlier, we used the *score variables* as a proxy to the strategic decisions. The first hypothesis is than that performance is linearly related to the *score variables.*

Hypothesis I

> *The firms' performance is linearly related to the strategic choices undertaken*

Based on the underlying theoretical framework developed for testing hypothesis I, we tested the hypothesized linear relationships using a set of stepwise regressions. Using these models, we expect to explain the performance of the companies depending on the strategic decisions they undertook.

Since we use the backwards method for selecting the independent variables, the starting model for explaining each of the dependent variables was:

$$\begin{aligned} Y_j = \beta_{0,j} + \beta_{1,j}TA + \beta_{2,j}CS\_SA + \beta_{3,j}CS\_GS + \beta_{4,j}CA\_S + \\ + \beta_{5,j}CA\_A + \beta_{6,j}BE\_P + \beta_{7,j}BE\_I + \beta_{8,j}BANC\_SEG + \varepsilon \end{aligned} \tag{5}$$

$H_0: \beta_{1,j} = \beta_{2,j} = \beta_{3,j} = \beta_{4,j} = \beta_{5,j} = \beta_{6,j} = \beta_{7,j} = \beta_{8,j} = 0$

$H_1: \beta_{1,j} \neq 0 \vee \beta_{2,j} \neq 0 \vee \beta_{3,j} \neq 0 \vee \beta_{4,j} \neq 0 \vee \beta_{5,j} \neq 0 \vee \beta_{6,j} \neq 0 \vee \beta_{7,j} \neq 0 \vee \beta_{8,j} \neq 0$

Where:

Yj = Performance variable chosen from the group presented above, that is, the average return on turnover (AROT), the average growth rate of turnover (AGRT) or the average return on assets (AROA).

All three regression models were computed using the backwards stepwise linear regression with the t-statistic as the criteria for selecting the exiting variable and the adjusted R-square as the objective to optimize. That is, the backwards method of the stepwise regression removed the independent variable that offered the worst t-statistic until the adjusted R-squared started dropping.

The results of the process are shown in tables 3, 4 and 5 for the average return on turnover (AROT), the average growth rate of turnover (AGRT) and the average return on assets (AROA), respectively.

[Insert Tables 3,4 and 5]

The stepwise linear regression approach provided a reasonable regression for explaining the average return on turnover (AROT), with an F-statistic significant at 0,001, and a barely acceptable regression for explaining the average return on assets (AROA), with an F-statistic significance of 0,034. As we could expect given the lack of significant correlation coefficients between the score variables and the average growth rate of turnover (AGRT), this relationship is not likely to be linear, since the stepwise regression could not reach an acceptable F-statistic.

For the two acceptable regressions, we realize that most of the significant score variables are common for both performance variables. The variable "Bank_Ins" stored "1" for banks and "2" for insurance companies, and reports that banks are likely to show both better average returns on turnover and better average returns on assets than insurance companies.

Technology adoption (TA) shows surprisingly a negative impact on both average returns on turnover (AROT) and average returns on assets (AROA). That may be related to the fact that the information technology adoption process seems to follow a pattern of successive investment cash outflows, as found by Gonçalves, Palma-dos-Reis and Duque [1999]. Therefore, despite a positive, even though non-significant, relation between the average growth rate of turnover (AGRT) and the adoption of information technology, we observed a growing need for new investments in technology, reducing the average return on assets, due to the increase on the assets.

It should be mentioned that a previous regime of nationalized banks and insurance companies left no room for competition and, therefore, no need for technological renewal. So, when the privatization program started and the competition returned, new investment was needed and a heavy investment program in information technology was initiated causing a long period of negative cash flows.

Regarding the competitive strategies, we find their positive impact in both performance variables. The strategies of geographic expansion (CS_GS) impact the average return on turnover positively, while both the strategies of geographic expansion (CS_GS) and the strategic alliances (CS_SA) impact the average return on assets positively.

These results are consistent with the recent development of the Portuguese financial services industry. The Portuguese financial sector has been under a wave of acquisitions associated with an increased geographical expansion. More retail outlets within Portugal and an expansion to other regions have been a characteristic of the recent development. Therefore, it should be expected that the importance given to competitive strategies either by strategic alliances or by geographical expansion would have a significant impact on some performance variables.

Curiously, the managers' perception that the business environment competitiveness is increasing (BE_I) is positively related both with the firm's average return on turnover (AROT) and on the average return on assets (AROA). This supports the relevance of the managers' perceptions for firms performance. More attentive managers are likely to get firms to perform better. The negative impact of the competitive aspects that the firm should consider (CA_S) on the average return on turnover (AROT) also supports the relevance of the managers' perceptions, even though the issue on this item is the gap between the competitive aspects that are actually considered and the ones that should be considered.

Neural Network Analysis

Even though the linear analysis offered promising results, we built and trained a neural network to forecast performance, given the firm's strategic decisions. We selected the neural network approach since neural networks are known for modeling nonlinear relationships that other models are unable to capture. Indro et al. [1999] found that artificial neural networks (ANN) generate better forecasting results than linear models for all types of mutual funds; Zhang et al. [1999] found that neural networks are significantly better than logistic regression models in prediction, as well as classification rate estimation. They (Zhang et al. [1999]) also report that neural networks are robust to sampling variations in overall performance classification.

The use of neural networks in financial decision-making has been growing rapidly [Zahedi 1993]. According to Enrado [1994] the use of neural networks by Mellon Equity Associates provided fairly significant improvements to the security selection process. Wong et al [1992] designed the Intelligent Security Selection (ISS) that included company, industry, economic, and country data.

Hypothesis II

> *A nonlinear model such as the neural networks can provide a better fit for explaining the firms' performance than the linear model*

In order to test hypothesis II, we developed and trained the neural network shown in Figure 1. The firm's performance, measured as the average return on turnover (AROT), the average growth rate of turnover (AGRT) and the average return on assets (AROA), is explained based on the nature of the firm, that is, whether the firm is a bank or an insurance company, and on the firm's strategic decisions and environment. The firm's strategic decisions and environment included the adoption of technology (TA), competitive strategies based on geographical expansion (CS_GS), the attention that the manager feels should be placed on competitive aspects (CA_S), the attention that the manager actually places on competitive aspects (CA_A), the present competitiveness of the business environment (BE_P), and whether the competitiveness on business environment is increasing or decreasing (BE_I). Since the strategic alliances (CS_SA) were never significant, or close to significant, in the linear regressions and, on the preliminary testing with neural networks, never provided a reasonable contribution, its input neuron was deactivated.

[Insert Figure 1]

The neural network consisted of three hetero-associative layers of neurons: The input layer, the hidden layer, and the output layer. Each of the three neurons in the hidden-layer processed the inputs using the sigmoid transfer function, which is:

$$Output(i) = \frac{1}{1 + e^{-Gain.Input(i)}} \qquad (6)$$

The network learning followed the Delta learning rule using the backpropagation control strategy. The neural network architecture is summarized in Table 6.

[Insert Table 6]

After 80,000 iterations, the neural network estimates for the firms' performance indicators explained most of the variability of the firms' performance. As shown in Table 7, the r-squares for the average return on turnover (AROT), the average growth rate of turnover (AGRT) and the average return on assets (AROA) are, respectively, 0.6030, 0.7050 and 0.8099, all of which are several points above the results obtained using the linear regressions.

[Insert Table 7]

In order to evaluate the model significance, we computed the F-test for each of the independent variables, as shown in Table 7. The degrees of freedom, *k*, were estimated as the number of parameters (in this case weights) from the input layer to the hidden layer (8 x 3 = 24), plus the number of parameters from the hidden layer to the output layer (3 x 3 = 9), divided by 3, since the neural network estimates three independent variables, minus 1, since the parameter "intercept" on the linear regression is not considered fot the estimation of *k*. Such number, ((24 + 9) / 3) – 1, is 10.

The F-statistic was computed, according to Mendenhall and Sincich [1989], as:

$$F = \frac{\left(R^2/k\right)}{\left(1 - R^2\right)/\left[n - (k+1)\right]}$$

(7)

where n is the number of observations and k is the number of parameters beyond the intercept.

The F-test rejected the null hypothesis of a random model for all three independent variables, what further supports the superior fit provided by the neural networks, compared to the fit provided by the stepwise backwards linear regressions.

The neural network training defined the weights that each of the inputs got on the hidden layer, which are shown in Table 8, and the weight each of the hidden layer neurons got on the output neurons, which are shown in Table 9.

[Insert Tables 8 and 9]

In order to evaluate how much each of the input variables may contribute for the performance indicators, we combined the neural network weights on tables 8 and 9 into global input-to-output weights adjusted to a –1 to 1 range. This was possible, without major distortions of the neural network structure, because the output layer neurons do not hold transfer functions and each of the intermediate layer neurons is only connected to two output layer neurons.

The raw global weights were computed as:

$$RGW_{ip} = \sum_{h=1..3} w_{i,h} \times w_{h,p} \tag{8}$$

where i stands for the input variable number; h stands for the hidden layer, or intermediate layer, neuron number; p stands for the performance variable number; $w_{i.h}$ stands for the weight the input variable i has on the intermediate neuron h; $w_{h.p}$ stands for the weight the intermediate neuron h has on the performance variable p; and $RGW_{i,p}$ stands for the raw global weight the input variable i has on the performance variable p.

In order to provide the reader with more understandable weights, the weights were adjusted to range between –1 and 1. Such adjustment was carried as:

$$GW_{ip} = \frac{\left(RGW_{ip} - \underset{i=1}{\overset{7}{Min}}(RGW_{ip})\right) \times 2}{\underset{i=1}{\overset{7}{Max}}\left(RGW_{ip}\right) - \underset{i=1}{\overset{7}{Min}}\left(RGW_{ip}\right)} - 1 \tag{9}$$

The global weights, presented in Table 10, confirm the results obtained when using the linear regression analysis. They show that banks are likely to have all three performance indicators better than insurance companies, that the adoption of technology (TA) is only beneficial to the average growth rate of turnover (AGRT) and that firms with geographical strategies (CS_GS) are likely to perform better.

The global network weights also suggest that firms are likely to perform better if they identify more competitive aspects they actually pay attention to (CA_A) and less competitive aspects that they should be paying attention to (CA_S). In terms of business environment (BE), it seams that, for the average return on turnover (AROT) and the average return on assets (AROA), firms that identify less present but more increasing competitive pressure seam to do best, while for the average growth rate of turnover (AGRT) the opposite seams to happen.

5. Discussion

As explained earlier, we started by searching one-to-one linear relationships using the Pearson's correlation coefficients. The results, presented in Table 2, do not show to many significant relations among score and performance variables. At the 0.05 significance level, we can only find the relationship between the geographical expansion strategies (CS_GS) and the average return on turnover (AROT), while at the 0.10 significance level we can find the relationships between the geographical expansion strategies (CS_GS) and the average return on assets (AROA), between the competitive aspects actually considered (CA_A) and the average return on assets (AROA) and between the perception of increasing competitiveness in the business environment (BE_I) and the average return on turnover (AROT).

The scarcity of significant linear relations lead us to consider three possible situations: (1) the relationship between score and performance variables might be week; (2) the relationship between score and performance variables might be nonlinear; or (3) the relationship between score and performance variables depends on the combination of score variables.

In order to search for the best linear regression, we run stepwise backwards linear regressions that started with all the variables available as independent variables and proceeded removing the least significant variable until the adjusted R-square started dropping. This procedure lead us to a reasonable explanation of the average return on turnover (AROT), a barely acceptable explanation of the average return on assets (AROA) and an unusable regression on the average growth rate of turnover (AGRT).

Afterwards, we built and trained a neural network that adjusted its parameters towards estimating sets of performance variables composed of the average return on turnover (AROT), the average growth rate of turnover (AGRT) and the average return on assets (AROA). The neural network, since using the sigmoid transfer function, released the linearity assumption, and the connections of each of the middle layer neurons with two of the performance variables allowed the neural network to adjust to effects of combinations of score variables, while permitting tracking the contribution of each of the score variables to the performance variables.

The nonlinear capabilities of the neural network allowed it to show a much higher R-square than the linear regressions: The neural network's R-square for the average return on turnover (AROT) is 0,60, while the linear regression's R-square is 0,54; the neural network's R-square for the average growth rate of turnover is 0,70, while the linear regression's R-square is 0,17; and the neural network's R-square for the average return on assets (AROA) is 0,81, while the linear regression's is 0,38.

Even though the neural network's adjustment showed to be much better than the linear regression's adjustment, the relevant score variables and the nature of their impact on the performance variables is very similar in both approaches.

Both approaches show that banks are likely to have all three performance indicators better than insurance companies, that TA has a negative impact on the average return on turnover (AROT) and on the average return on assets (AROA), that firms with geographical strategies (CS_GS) are likely to perform better, and that managers identifying high scores on attention that should be given to competitive aspects (CA_S) has a negative impact on the average return on turnover (AROT).

In terms of business environment (BE), it seams that, for the average return on turnover (AROT) and the average return on assets (AROA), firms that identify more increasing competitive pressure seam to do best.

The duality between the attention that should be paid to competitive aspects (CA_S) and the attention actually paid to competitive aspects (CA_A), as well as the duality between the managers' perception of competitiveness in the current business environment *versus* the managers' perceptions of increasing competitiveness in the business environment, showed the superior capabilities of neural networks to handle the effects of relationships between independent variables on de dependent variable.

The linear regression handles effectively the most relevant of each pair of variables, the one reflecting the perspectives of the manager about the future or the desirable situation, that is, the linear regression considers the level of attention that the managers feel should be paid to the competitive aspects and the managers' perceptions of increasing competitiveness in the business environment.

On the other hand, the neural network is able to consider that attention actually given to competitive aspects has a positive impact on performance while feeling the need to pay attention to competitive aspects has a negative impact on performance.

6. Conclusions

This paper supports the existing literature on the relationship between business environment and perspectives, strategic choices, and performance. The analysis of the data collected using the stepwise backwards linear regression and neural networks lead us to the following conclusions:

- Firms with geographical expansion strategies are likely to perform better;
- Firms with managers considering that more attention should be paid to competitive aspects are likely to have a lower average return on turnover (AROT), while firms which managers consider that plenty of attention is currently given to competitive aspects are likely to perform better;
- Firms with managers considering that the business environment is becoming more competitive do better than the ones which managers do not have such perception;
- Surprisingly, firms adopting more technology are likely to have less average return on turnover (AROT) and less average return on assets (AROA). However, they are likely to have a better average growth rate of turnover (AGRT);
- Banks are likely to have better performance than insurance companies.

Regarding the methodologies used, the neural networks provided better results than the stepwise linear regression, not only in terms of the percentage of variability of the independent variables explained (R-square), but also by accommodating variables with high levels of multicolinearity, as well as nonlinear relationships.

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Table 1 - Assets and Turnover in 1995

	Banks		Insurance Companies		Total	
	10^9 US$	%	10^9 US$	%	10^9 US$	%
Total Industry Assets	263,936		13,989		277,925	
Total Sample Assets	162,340	61.5	7,990	39,5	170,330	61.3
Total Industry Turnover	34,135		4,707		38,841	
Total Sample Turnover	20,800	60.9	1,637	34.8	22,437	57.8

Table 2 – Pearson's Correlation Coefficients

	AROT	AGRT	AROA
TA	-0.0666	0.1946	-0.1870
	p=0.359	p=0.147	p=0.153
CS_SA	0.1174	0.0111	0.1646
	p=0.261	p=0.476	p=0.184
CS_GS	0.3690	0.0212	0.2366
	p=0.021	p=0.456	0.100
CA_S	-0.2214	-0.0657	-0.2171
	p=0.112	p=0.363	p=0.116
CA_A	-0.1393	0.1235	-0.2453
	p=0.227	p=0.258	p=0.092
BE_P	0.1128	0.0954	0.0041
	p=0.269	p=0.305	p=0.491
BE_I	0.2354	-0.1120	0.1515
	p=0.097	p=0.274	p=0.204

Table 3 – Stepwise Linear Regression for Explaining the Average Return on Turnover (AROT)

Method:		Stepwise backwards	
Exit criteria for independent variables:		Least significant variable until the Adjusted R-Square drops	
Variable	**B**	**t-statistic**	**Sig(t)**
(Constant)	0,152	0,566	0,577
BANC SEG	-0,125	-2,337	0,028
TA	-0,107	-2,662	0,014
CS_GS	0,066	2,169	0,040
CA_S	-0,110	-1,634	0,115
BE_I	0,151	2,782	0,010
F-statistic:	5,611	**Sig(F):**	0,001
R-Square:	0,539	**Adjusted R-Square:**	0,443

R-Square with all 8 variables: 0,545

Table 4 – Stepwise Linear Regression for Explaining the Average Growth Rate of Turnover (AGRT)

Method:		Stepwise backwards	
Exit criteria for independent variables:		Least significant variable until the Adjusted R-Square drops	
Variable	**Beta**	**t-statistic**	**Sig(t)**
(Constant)	1,161	1,479	0,152
TA	0,230	1,557	0,132
BE_P	0,408	1,631	0,115
BE_I	-0,721	-2,016	0,055
F-statistic:	1,678	**Sig(F):**	0,197
R-Square:	0,168	**Adjusted R-Square:**	0,068

R-Square with all 8 variables: 0,211

Table 5 – Stepwise Linear Regression for Explaining the Average Return on Assets (AROA)

Method:		Stepwise backwards	
Exit criteria for independent variables:		Least significant variable until the Adjusted R-Square drops	
Variable	**Beta**	**t-statistic**	**Sig(t)**
(Constant)	-0,087	-0,718	0,480
BANC SEG	-0,051	-1,602	0,122
TA	-0,072	-3,364	0,003
CS_SA	0,016	1,064	0,298
CS_GS	0,032	1,740	0,095
BE_I	0,048	1,616	0,119
F-statistic:	2,907	**Sig(F):**	0,034
R-Square:	0,377	**Adjusted R-Square:**	0,247

R-Square with all 8 variables: 0,427

Table 6 – Neural network architecture

Issue	Choice
Number of input neurons	7
Number of hidden layer neurons	3
Number of output neurons	3
Connection type	Hetero-associative
Transfer function on the hidden layer	Sigmoid
Learning rule	Delta
Control strategy	Backpropagation

Table 7 – Evaluation of the neural network estimates for the financial performance indicators

	AROT	AGRT	AROA
R-square	0,6030	0,7050	0,8099
v1=k	10	10	10
v2=n-(k+1)	18	18	18
F-statistic	2,7336	4,3019	7,6709
Sig(F)	0,0305	0,0035	0,0001

Table 8 – Input weights on the hidden layer neurons

	BANK / INSUR.	TA	CS_GS	CA_S	CA_A	BE_P	BE_I	ERROR
W(10)	0,5614	0,8022	0,4031	0,4622	1,1801	1,9064	-1,1716	-3,1557
W(11)	-1,0304	-2,2202	1,0063	-0,6906	0,1682	-1,0143	2,4973	3,1649
W(12)	-0,5561	-0,5775	0,1233	-0,9763	-1,3001	-0,6297	0,4781	-1,4414

Table 9 – Weights of the hidden layer neurons on the output variables

	ERRO	N10	N11	N12
AROT	-0,5369	0,1452	1,1975	0,0000
AGRT	0,0363	1,3999	0,0000	0,9630
AROA	-0,3579	0,0000	1,1160	-0,0489

Table 10 – Global network weights

	BANC SEG	TA	CS_GS	CA_S	CA_A	BE_P	BE_I
GlobalWeight(AROT)	-0,4625	-1	0,629116	-0,30219	0,113942	-0,43426	1
GlobalWeight(AGRT)	-0,23873	0,208385	0,257859	-0,62417	0,007687	1	-1
GlobalWeight(AROA)	-0,46088	-1	0,567417	-0,29113	0,062894	-0,50822	1

29	BANC SEG	TA	CS_SA	CS_GS	CA_S	CA_A	BE_P	BE_I	*AROT*	*AGRT*	*AROA*	*AGRCF*	*ACFOTA*	ERRO	N10	N11	N12	O(AROT)	O(AGRT)	O(AROA)	E(AROT)	E(AGRT)	E(AROA)
	-1	0,340	0,048	0,714	0,80	0,43	0,85	1,00	0,59	-0,70	0,73	-0,76	-0,82	1,00	0,14	1,00	0,08	0,675	0,311	0,749	0,016	0,395	-0,004
	-1	0,465	-0,048	0,679	0,80	0,29	0,70	1,00	0,55	-0,58	0,73	-0,69	-0,82	1,00	0,10	0,99	0,10	0,668	0,274	0,747	0,014	0,320	-0,004
	-1	0,267	-1,000	-0,036	0,80	-0,43	0,63	0,30	0,41	-0,73	0,69	-0,83	-0,84	1,00	0,06	0,96	0,18	0,615	0,289	0,700	0,000	0,351	-0,011
	-1	-0,111	-0,238	-0,393	-0,20	0,57	0,56	0,57	0,44	-0,77	0,70	1,00	-0,84	1,00	0,05	0,99	0,18	0,661	0,280	0,743	0,012	0,332	-0,005
	-1	0,554	-0,333	0,679	0,50	0,64	0,41	0,48	0,55	-0,68	0,72	-0,82	-0,80	1,00	0,14	0,99	0,08	0,663	0,311	0,738	0,013	0,395	-0,006
	-1	0,320	-0,619	-0,036	0,10	-0,14	0,56	0,57	0,43	-0,73	0,70	-0,93	-0,82	1,00	0,04	0,99	0,26	0,649	0,338	0,729	0,009	0,449	-0,007
	-1	0,600	0,429	1,000	1,00	0,79	0,33	0,83	0,61	-0,60	0,73	-0,77	-0,80	1,00	0,14	0,99	0,05	0,674	0,288	0,748	0,015	0,349	-0,004
	-1	0,444	-0,429	-0,036	-1,00	0,14	0,26	0,22	0,82	-0,07	0,78	-0,34	-0,84	1,00	0,03	0,98	0,40	0,647	0,463	0,722	0,008	0,703	-0,008
	-1	-0,558	-0,429	0,857	-0,80	0,14	0,19	-0,30	0,53	0,30	0,68	-0,84	-0,83	1,00	0,04	1,00	0,47	0,663	0,537	0,732	0,012	0,870	-0,006
	-1	-0,713	-1,000	-0,714	-0,50	-0,07	0,04	0,04	0,46	0,01	0,70	-0,80	-0,85	1,00	0,01	1,00	0,50	0,657	0,533	0,729	0,011	0,859	-0,007
	-1	1,000	0,524	0,571	0,50	0,64	0,78	0,48	0,63	-0,01	0,75	-0,80	-0,85	1,00	0,31	0,94	0,05	0,632	0,524	0,687	0,004	0,838	-0,013
	1	-1,000	-0,429	-0,714	-0,30	-0,79	0,33	-0,22	0,31	-0,63	0,63	-0,62	-0,52	1,00	0,02	0,94	0,38	0,597	0,427	0,678	-0,006	0,628	-0,014
	1	-0,805	0,067	-0,750	0,80	0,57	0,56	0,04	0,50	-0,67	0,73	-0,82	1,00	1,00	0,18	0,91	0,03	0,574	0,323	0,651	-0,012	0,419	-0,018
	1	-0,844	-1,000	-0,571	0,30	-0,50	1,00	0,74	1,00	-1,00	0,86	-0,81	-0,72	1,00	0,05	0,98	0,18	0,646	0,284	0,729	0,008	0,341	-0,007
	1	-0,422	-0,619	-0,714	-0,60	0,14	-1,00	-1,00	-0,34	-0,80	0,11	-0,88	-0,47	1,00	0,02	0,79	0,22	0,408	0,268	0,510	-0,058	0,307	-0,037
	1	-0,713	-0,250	-1,000	-0,10	0,11	0,83	0,26	0,31	-0,67	0,64	-0,95	-0,71	1,00	0,10	0,93	0,10	0,593	0,276	0,676	-0,007	0,324	-0,014
	1	-0,353	-0,619	-0,571	0,10	0,50	0,78	0,74	0,34	-0,91	0,66	-0,86	0,80	1,00	0,14	0,97	0,06	0,642	0,284	0,720	0,007	0,340	-0,008
	1	-0,578	-0,143	-0,714	-0,10	0,36	0,33	0,30	0,39	-0,69	0,69	-0,79	-0,14	1,00	0,06	0,96	0,10	0,625	0,223	0,711	0,002	0,209	-0,009
	1	0,022	-0,905	0,857	0,30	0,14	0,11	0,22	0,30	-0,63	0,64	-0,77	-0,08	1,00	0,12	0,96	0,09	0,631	0,292	0,710	0,004	0,357	-0,009
	1	-0,777	-0,429	-0,929	-0,10	-1,00	0,48	0,22	-0,47	0,28	0,58	-0,69	-0,25	1,00	0,02	0,95	0,39	0,599	0,429	0,680	-0,005	0,633	-0,014
	1	-0,374	-1,000	0,679	-0,85	0,90	0,26	0,22	0,61	-0,67	0,95	-0,75	0,15	1,00	0,15	0,99	0,11	0,672	0,356	0,742	0,015	0,485	-0,005
	1	-0,689	-0,714	-0,571	-0,30	0,00	0,70	0,30	0,31	-0,32	0,62	-0,78	-0,12	1,00	0,07	0,97	0,16	0,630	0,291	0,712	0,004	0,356	-0,009
	1	-0,867	0,619	-0,571	-0,30	0,29	-0,85	0,13	0,42	-0,65	0,71	-0,79	-0,31	1,00	0,01	0,99	0,26	0,653	0,295	0,737	0,010	0,363	-0,006
	1	-0,244	-0,714	-0,714	-0,20	-0,17	0,63	0,39	0,03	-0,63	0,46	-0,79	-1,00	1,00	0,07	0,92	0,15	0,571	0,274	0,659	-0,012	0,321	-0,016
	1	-0,001	1,000	0,143	-0,20	0,43	0,93	0,65	0,10	0,00	0,44	-0,79	-0,29	1,00	0,25	0,96	0,07	0,648	0,446	0,710	0,009	0,666	-0,009
	1	-0,156	0,810	0,286	-0,60	-0,57	0,33	0,22	0,62	-0,44	0,83	-0,79	-0,57	1,00	0,04	0,96	0,34	0,623	0,423	0,701	0,002	0,619	-0,011
	1	-0,933	-1,000	-1,000	-0,76	0,10	0,45	0,44	0,83	-0,70	1,00	-0,82	0,51	1,00	0,03	0,99	0,26	0,649	0,322	0,732	0,009	0,417	-0,006
	1	0,267	-0,143	-0,571	0,50	0,36	0,70	0,65	0,46	-0,72	0,74	-0,81	-0,63	1,00	0,20	0,83	0,04	0,488	0,352	0,568	-0,035	0,477	-0,029
	1	0,444	-1,000	-0,714	0,80	1,00	0,85	0,48	-1,00	1,00	-1,00	-1,00	-0,28	1,00	0,52	0,59	0,01	0,249	0,775	0,303	-0,112	2,626	-0,071
Weight(N10)	0,5614	0,802		0,403	0,46	1,18	1,91	-1,17						-3,16									
Weight(N11)	-1,0304	-2,220		1,006	-0,69	0,17	-1,01	2,50						3,16									
Weight(N12)	-0,5561	-0,578		0,123	-0,98	-1,30	-0,63	0,48						-1,44									
Weight(AROT)														-0,54	0,15	1,20	0,00						
Weight(AGRT)														0,04	1,40	0,00	0,96						
Weight(AROA)														-0,36	0,00	1,12	-0,05						
Média	0,2413793	-0,187	-0,330	-0,167	0,01	0,17	0,44	0,34	0,37	-0,46	0,63	-0,73	-0,44	1,00	0,11	0,95	0,18	0,610	0,362	0,688	-0,002	0,543	-0,013
RSQ																		0,598	0,805	0,791	0,603	0,705	0,810
STEYX																		0,058	0,053	0,042			
																							2,071
v1=k																					10	10	10
v2=n-(k+1)																					18	18	18
F-statistic																					2,7336	4,3019	7,6709
Sig(F)																					0,0305	0,0035	0,0001