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Technological Level of Enterprises in Some Brazilian Industrial Sectors

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Abstract

The objective of this study was to verify the technological level of enterprises from different industrial sectors in the State of São Paulo, Brazil.

A quantitative research with 165 executives from domestic and multinational companies was conducted between July 2004 and July 2006. A list of technological techniques or tools was presented to the interviewees for them to grade these from 1 to 7 in terms of the implementation of each one of these aspects at their company.

The technique of factor analysis was applied and an index of technological degree was obtained, as the weighted average of factor scores with weights that corresponded to the percentage of variance accounted for each factor. The ensuing ranking of companies provided the relative position of each one in terms of technological advance.

Keywords:

Technological level, Industrial sectors, Multivariate data analysis

1. INTRODUCTION

The technological level of companies reflects to what extent they have accompanied the evolution of methods, techniques and equipment over the years in various activity sectors. The available literature gives a most varied range of technological alternatives, although there are few texts that consider the technological level of companies (PLANTULLO, 2006). From what we have observed the texts pertinent technological level are not conclusive, and sometimes confused even the concept's technical terms. It is not uncommon to find texts that indiscriminately use, among others, terms like science, technology, technological platform, level of software implementation and hardware. There is also the problem that a technological advance very much above the average is expected when buying sophisticated equipment, and without the necessary training and development of qualified professionals.

In another strand we see a great number of texts linked to training and development models for industrial company employees, which are all very interesting at the theoretical level. However, generally speaking, they are of no practical application. A possible reason for the under-use of these models is the concern with short and medium-term results, without evaluating the long-term nature of the business (HENDRICKSEN, 1977).

This study was motivated to respond to the following questions:

a) What variables are most used for the technological development of industrial companies?

b) What level of technology do these industrial companies have?

c) What is the position of industrial companies on a ranking of technological development?

The central objective of this article is to present the variables that reflect the technological level of companies, by applying statistical techniques.

In a widely globalized economy that is immersed in the digital-neural era (PLANTULLO, 2006), knowledge of the advance of companies in the technological context and the position of each of them relative to other companies from the same sector allows us to reflect on the competitive differential of the ranking leaders and the need for adjustments to be made by those occupying positions in disadvantageous conditions when it comes to strengthening themselves and facing up to the constant challenges of the business environment.

2. THEORETICAL FOUNDATIONS

We need to explain here the differences between science and technology. Science is understood to be acquired knowledge, although not all knowledge is considered scientific. Scientific knowledge goes through a methodical and systematic preparation process, in such a way that its statements and proposals may be accepted as true. Science can be understood as a set of individual pieces of scientific knowledge, or as the systematic and ordered activity needed to obtain this knowledge. Longo (1979: 3-

19) defines science as "*the organized set of pieces of knowledge relative to the objective universe, involving its natural, environmental and behavioral phenomena*". For Sábato, however *after* Barbieri (1983: 27), "*it is the human activity, the objective of which is the search for knowledge about nature through the application of the set of rules that constitutes the scientific method*". This said, science can be basic (pure and/or fundamental research), or applied, according to one of the countless classification criteria. Both use the scientific method, but in basic science or research, the search for knowledge is not linked to practical objectives, as it is in applied science or research (RUSSELL, 1963). According to Bunge (1980: 28), while in basic science researchers study the problems they are interested in, for specific motives, in applied science they study problems that are of possible social interest. It is worth highlighting that what both have in common is the fact that their objective is the search for knowledge that might explain the reality and the methods for obtaining it. By technology we understand the knowledge of techniques or arts, recognized as meaning skills or functions. The basic characteristic of technology is to be essentially useful. For Schon (1967:1), technology is any tool or technique, production or process, equipment or manufacturing method that extends human capacity. Figueiredo (1972: 60) defines it as the "*sum of pieces of knowledge of a scientific or technical nature that are required to introduce a given industrial activity and make it function*". A more all-embracing understanding is supplied by Longo (1979: 4): "*technology is an ordered set of all the knowledge — scientific, empirical or intuitive — used in the production and commercialization of goods and services*". Sábato, *after* Barbieri (1983:5) observes that "*the set of suggested pieces of knowledge that defines a certain technology must be ordered, organized and articulated*". Technology, as "*an ordered, organized and articulated set of pieces of knowledge*", may, or may not be incorporated into the physical or tangible goods. In the first case, implicit, or incorporated technology, this knowledge materializes in the shape of physical capital assets and production inputs. On the other hand, in explicit, or non-incorporated technology, the knowledge is contained in documents and people with their skills, experiences and professional capabilities.

In short, the resources pertinent to the new product research and development area, articles, processes, services and information must be sub-divided into a few items, namely: resources destined for pure and applied research and for actual development.

The resources destined for pure research involve large sums of money and are included in what is known as *sunk costs* (HENDRIKSEN, 1977); maturity times are extremely long because of the uncertainties that exist in the environment. Pure research is a function, within research and development (R & D) that seeks the immediate application of concepts, methodologies, philosophies and theories developed at the global level and that must be adapted to the capitalist industrial company. However, in the majority of industrial, commercial, service provider and information companies it still leaves a lot to be (ROUSSEL *et al.,* 1992).

With regard to applied research, it is necessary to spend a considerable amount of money, but the application and maturity timescale is considerably shorter, which makes applications of an industrial nature feasible.

With regard to the development function we need to understand that it is applied in manufacturing process inputs, with the help of engineering, machinery and equipment maintenance, purchases and supplies, on and off-line quality control and training and development. This function starts with small batches being made, with a view to the final tests before its introduction in global markets (SUZAKI, 1993). Results are quantifiable in the short term and essentially practical. The relationship of this function with the others is discrete, but very far below what is desirable for process optimization.

Various pieces of work deal with aspects linked to technology and the planning of technological development in companies. In the light of these publications some variables were selected to reflect the technological level of industrial companies. The variables we researched in this work with a group of companies will be presented in the section referring to methodological aspects.

In selecting the variables relating to the technological level we focused on some of the aspects found in the works of authors that have dedicated themselves to the theme of technology. Table 1 gives a summary of the aspects and respective authors:

Table 1: Technology Aspects

Aspects	Authors
Intelligent information technology - Q1a	Castelltort (1988), Scheer (1993), Rich and Knight (1994), Meirelles (1995), Kovács (1996), Prigogine (1996), Krajewsky and Ritzman (1999), Nussenzveig (2003) and Plantullo (2006)
Production methodologies - Q1b	Feigenbaum (1951), Goldratt and Cox (1984), Juran (1988), Osada (1989), Taguchi *et al.* (1990), Suzaki (1993), Deming (1990)
Finance methodologies - Q1c	Kaplan and Johnson (1987) and Cogan (2006)
Management philosophies - Q1d	Tomasko (1993), Hammer and Champy (1994), Morgan (1996), Santos (2005)
Level of integration - Q1e	Ansoff (2001) and Hamel and Prahalad (2005)
Strategic planning - Q1f	Roussel *et al.* (1992), Porter (2001), Ansoff (2001) and Hamel and Prahalad (2005)

3. METHODOLOGICAL ASPECTS

For the focus on variables corresponding to technological development, we arrived at the aspects presented in Table 2 below.

Table 2: Names of Variables

Names of the Variables	Theoretical support – Aspects of Table 1
V1. Small Group Activities (SGAs)	Q1b
V2. Quality Control Circles (QCCs)	Q1b
V3. Computer - aided Design (CAD)	Q1a
V4. Computer - aided Engineering (CAE)	Q1a
V5. Computer - aided Information Technology (CAIT)	Q1a
V6. Computer - aided Instruction (CAI)	Q1a
V7. Computer - aided Manufacturing (CAM)	Q1a
V8. Computer - aided Process Planning (CAPP)	Q1a
V9. Computer - aided Technology (CAT)	Q1a
V10. Computer - aided Testing (CATE)	Q1a
V11. Computer - integrated Manufacturing (CIM)	Q1a
V12. Connectivity Among Systems (CAS)	Q1a
V13. Statistical Quality Control (SQC)	Q1b
V14. Total Quality Control (TQC)	Q1b
V15. Activity-based Costing (ABC)	Q1c
V16. Downsizing (DW)	Q1d
V17. Integrated Process and/or Manufacturing Strategy (IPMS)	Q1f
V18. Integrated Information Technology Strategy (IITS)	Q1f
V19. Taguchi Functions (TF)	Q1b
V20. Activity-based Management (ABM)	Q1c
V21. Total Quality Management (TQM)	Q1b
V22. Global Sourcing (GS)	Q1b
V23. Just-in-Case (JIC)	Q1b
V24. Just-in-Time (JIT)	Q1b
V25. Total Productive Maintenance (TPM)	Q1b
V26. Organizational Change – Transversal Organizations (OC-TOs)	Q1d, Q1f
V27. Knowledge-network Organizations (KNOs)	Q1d
V28. Outplacement (OP)	Q1d, Q1f
V29. Reverse Strategic Planning (RSP)	Q1f
V30. Traditional Strategic Planning (TSP)	Q1f
V31. Re-engineering (RE)	Q1d
V32. Rightsizing (RS)	Q1d, Q1f
V33. Specialist Systems integrated with Artificial Intelligence (SSIAI)	Q1a
V34. Group Technology (GT)	Q1b
V35. Flexibility Theory (FLEXT)	Q1b
V36. Artificial Intelligence Theory (AIT)	Q1a
V37. Resilience Theory (REST)	Q1b
V38. Neural Networks Theory (NNT)	Q1a
V39. Theory of Constraints (Goldratt) (TC)	Q1b
V40. Chaos Theory (CHT)	Q1a
V41. Finite Elements Theory (FET)	Q1b
V42. Complex Systems Theory (CST)	Q1a

Table 3 shows the study's planning and development phases, and the main results obtained:

Table 3: Phases of the Study

Seq.	Phases	Results
1	Bibliographic review of the concepts relevant to science, technology, pure research, applied research and others.	Greater theoretical foundation relative to the theme of the work.
2	Pilot-questionnaire preparation	Detection of any necessary adjustments for improving the collection instrument.
3	Qualitative research	Carried out with ten company executives, four of them from Brazilian companies and six from multinationals. The respondents tried to provide their own suggestions, criticisms, contributions and visions.
4	Quantitative research	Carried out with 165 company executives from Brazilian and multinational companies.
5	Analysis of results	Comprising seven phases, and presented in Section 4.

In the first phase of this research we read books, local and international periodicals, specialization essays, masters, PhD and post-PhD theses, with the idea of producing the theoretical archetype pertinent to technological level of industrial companies. In the second phase we built a pilot questionnaire with questions about the profile of the companies and their technological level variables. We prepared closed questions with 42 variables for measuring the technological level of local and multinational companies. In the third phase we applied the pilot questionnaire to ten executives, four of them from local companies and six from multinational companies, in order to refine the questions for the definitive version of the questionnaire. In the fourth phase we did the exploratory research with 165 executives and supervisors of national and multinational companies from various sectors of the economy. We would point out that, on average, each interview lasted approximately three to four hours, which is why this whole process took so long – practically two years, from July 2004 to July 2006. The final version of the questionnaire was in three parts:

Part A – General data about the company; Part B – Questions on the characteristics of the company's production process; Part C- Objective questions about the company's level of technological development.

In the fifth phase we linked the theoretical framework with the practical part, by applying statistical techniques.

The population we focused on in this study is made up of companies mentioned in Exame magazine's Biggest and Best survey of the 500 largest companies in Brazil in the period from July 1994 to July 2006 (SANTOS; CARVALHO, 2006). We also focused on some small companies in order to obtain a possible contrast in terms of technological performance. We researched 23 companies, each one having more than one respondent. We interviewed 165 executives, in all. The companies researched were: 3M, Alcoa, Bunge, Colgate-Palmolive, Daimler-Chrysler, DASA, Engemix, Festo, Galvanoplastia Mauá Lanxess, Magneti Marelli-Cofap, Makita, Microsiga, Multibrás, Pichinin, Romi, Sanches-Blanes, Semasa, Siemens, Sig-Simonazzi, Usimac, Votoran Cimentos and Votorantim Metais.

4. RESULTS ANALYSIS

Table 4 synthesizes the statistical techniques used and their respective objectives.

Table 4: Statistical Techniques Employed

Technique	Objective
Frequency distribution of missing values	To find out about the distribution of each variable and decide on the variables to be maintained.
Mahalanobis' Distance (D^2)	To identify outliers.
Kolmogorov-Smirnov Test and asymmetry and kurtosis measures	To test univariate normality.
Descriptive statistics	To obtain measures of central tendency and dispersion.
Cronbach's alpha coefficient	To test the reliability of the measurement of the technological variables' dimension
Factor analysis	To find the factor scores and reduce the number of variables.
Weighted average of the factor scores	To measure the technological level of the companies.

4.1 MISSING VALUES ANALYSIS

The missing values frequency is generally of the order of 10%. There are some variables to eliminate because they have a missing values rate greater than 10%, a number considered excessive in day to day practice, although Hair *et al.* (2005) do not mention a particular percentage, in other words, each case should be treated individually (HAIR *et al.*, 2005: 50-51, 58-60). We eliminated the variables: V2, V15 to V16, V19 to V20, V23, V26 to V28, V33, V36 to V38 and V40 to V42. In addition, we eliminated the variables V1, V12, V16, V24, V26 to V28 because they were not highly representative of the Technological Level of the companies we researched, and they also had a lot of synergy with the Essential Human Talents and Competencies (EHTC) area, the former Human Resources (HR) process.

4.2 OUTLIERS ANALYSIS

According to Hair *et al.* (2005: 72-73), it is necessary to check whether so-called points beyond observation, or outliers are present, or not. This being so it is important to calculate the distance of each observation relative to some common point. To do this we need to obtain the so-called Mahalanobis Distance in a multidimensional space for each observation relative to the mean center of observations, which would supply a common measure for multidimensional centrality. Hair *et al.* (2005) suggest a level of 0.001, or 0.1%, to indicate an atypical observation.

The identification of outliers was done for the variables that were maintained after analysis of the missing values.

Calculating Mahalanobis Distance (D^2) relative to the number of degrees of liberty of all 23 variables, we saw that the highest value was 2.820, with the critical value being 3.768, in other words, the highest value is smaller than the critical value. This result proves there are no outliers in the responses, indicating, to a certain extent, the stability of the study.

4.3 NORMALITY TEST

To test the normality of a particular variable we can use the Kolmogorov-Smirnov (K-S) Test. This test measures the degree of concordance between the distribution of a set of sample values (observed) and a particular theoretical distribution, thereby determining if the sample values can be reasonably considered as coming from a population with that distribution. This test considers the following hypotheses:

H_0: the data come from a normally distributed population

H_1: the data don't come from a normally distributed population

We noticed that the variables do not follow a normal distribution. According to Hair *et al.* (2005: 76), non-compliance with normality may be less relevant in the case of large samples. In addition, certain statistical techniques have no normality pre-requisite for variables. Given these two provisos, the non-normality in this study was not considered to be a concern.

4.4. DESCRIPTIVE STATISTICS

In this section we studied the main descriptive statistics of the variables maintained after analysis of the missing values. These were: Average, Median, Mode, Standard Deviation, Variance, Variation Coefficient, Asymmetry, Kurtosis, Range, Minimum and Maximum Value of the Variable.

Table 5 shows these statistics for the variables, using the following keys:

- AVE: Average, MD: Median, MOD: Mode, SDEV: Standard deviation, VAR: Variance, VC: Variation coefficient, ASS: Asymmetry, KUR: Kurtosis, RAN: Range, MINV: Minimum value and MAXV: Maximum value.

Table 5: Descriptive Statistics

VAR	AVE	MD	MOD	SDEV	VAR	VC	ASS	KUR	RAN	MINV	MAXV
V3	5.44	6	6	1.66	2.75	30.5	-1.35	1.10	6	1	7
V4	5.19	6	7	1.84	3.40	35.5	-0.96	-0.03	6	1	7
V5	4.79	5	7	1.90	3.60	39.7	-0.52	-0.86	6	1	7
V6	4.66	5	6	1.84	3.40	39.5	-0.48	-0.98	6	1	7
V7	5.03	6	6	1.89	3.57	37.6	-1.04	-0.07	6	1	7
V8	5.21	6	6	1.85	3.42	35.5	-1.00	-0.14	6	1	7
V9	4.73	5	6	1.84	3.38	38.9	-0.90	-0.27	6	1	7
V10	4.65	5	6	1.89	3.56	40.6	-0.70	-0.68	6	1	7
V11	4.75	6	6	2.04	4.16	42.9	-0.75	-0.78	6	1	7
V13	5.45	6	6	1.47	2.17	27.0	-1.08	0.71	6	1	7
V14	5.52	6	7	1.50	2.24	27.2	-1.03	0.63	6	1	7
V17	4.8	5	6	1.55	2.39	32.3	-0.65	-0.29	6	1	7
V18	4.92	5	6	1.62	2.63	32.9	-0.90	0.10	6	1	7
V21	5.32	6	6	1.50	2.24	28.2	-1.07	0.62	6	1	7
V22	5.11	6	6	1.69	2.86	33.1	-1.04	0.34	6	1	7
V25	5.15	5	6	1.46	2.13	28.3	-0.84	0.06	6	1	7
V29	4.33	5	6	2.01	4.05	46.4	-0.31	-1.15	6	1	7
V30	4.83	5	6	1.89	3.58	39.1	-0.67	-0.67	6	1	7
V31	4.34	4	6	1.74	3.01	40.1	-0.32	-0.80	6	1	7
V32	4.11	4	5	1.55	2.42	37.7	-0.5	-0.60	6	1	7
V34	4.23	4	4	1.78	3.18	42.1	-0.16	-0.95	6	1	7
V35	4.32	4	6	1.64	2.68	38.0	-0.29	-0.84	6	1	7
V39	3.19	3	1	2.04	4.14	63.9	0.35	-1.36	6	1	7

We need to point out that the values of the variation coefficients in percentage terms varied from 27% (V13) to 63.9% (V39). These results are evidence that there is a myriad of different responses. Furthermore, we saw that the variable V14 presented the greatest mean value: 5.52. On the other hand the variables V3, V4, V7 to V8, V11, V13 to V14, V21 to V22 had the greatest median values, while the greatest mode values were found in variables: V4 to V5 and V14.

4.5. CRONBACH'S ALPHA COEFFICIENT

According to Peter (1979), *after* Sobreira (2006, p. 115), the reliability of a measuring instrument is the extent to which its measures have minimum random errors; in other words, whether an instrument is capable of producing consistent results when repeated measurements are taken.

According to Hair *et al.* (2005, p.90), reliability is the degree by which a variable, or set of variables, proves to be consistent with what one intends to measure. This said, to analyze reliability we used Cronbach's alpha coefficient, which is capable of revealing the degree to which the items of an instrument are homogenous and reflect a certain implicit construct. According to Hair *et al.* (2005, p. 89-91), Cronbach's alpha coefficient is a measure of the reliability of sample data that varies between 0.00 and 1.00, with values between 0.60 and 0.70 being considered to be the lower limit of acceptability. This analysis will also make it possible to evaluate the sensitivity of this coefficient, by repeatedly calculating it, excluding each aspect of the dimension and comparing the results.

We came up with the value 0.9508, which is evidence of the existence of reliability in the measurement of the technological level dimension as far as the collected sample is concerned. If we eliminate the variable V34 this value goes up to 0.9509, and if this is also done with V39, the value reaches 0.9540. Since these increases were not significant, and adopting a conservative stance in the study model, we decided to maintain these variables. Table 6 gives the results:

Table 6: Cronbach's Alpha Test

Variables	Scale mean if a variable is deleted	Scale variance if an item is deleted	Total correlation	Multiple correlation to the square	Cronbach's alpha value if a variable is deleted
V3	105.7596	762.8446	0.7025	0.8268	0.9481
V4	105.7981	751.1530	0.7885	0.8936	0.9470
V5	106.1538	760.5975	0.6686	0.7616	0.9486
V6	106.5288	761.4943	0.6771	0.6667	0.9484
V7	106.0288	743.0380	0.8236	0.8959	0.9464
V8	105.9038	745.9907	0.7854	0.7754	0.9470
V9	106.1923	752.4093	0.7564	0.8182	0.9474
V10	106.2500	750.1893	0.8017	0.7959	0.9468
V11	106.2308	736.8394	0.8230	0.8506	0.9464
V13	105.4519	764.9103	0.8104	0.8171	0.9472
V14	105.4231	771.0426	0.7267	0.7512	0.9480
V17	106.2404	783.9902	0.5551	0.5634	0.9498
V18	106.0096	772.3397	0.6799	0.7676	0.9485
V21	105.5962	779.4081	0.6384	0.7425	0.9490
V22	105.8654	755.6516	0.7634	0.7955	0.9473
V25	105.8077	778.3316	0.6527	0.6674	0.9488
V29	106.7308	768.2375	0.5478	0.6572	0.9503
V30	106.0673	778.0634	0.5385	0.7849	0.9501
V31	106.6058	772.3771	0.6193	0.7387	0.9491
V32	106.8942	775.5324	0.6568	0.7213	0.9487
V34	106.6923	784.8753	0.4743	0.6830	0.9509
V35	106.7788	784.5040	0.4944	0.6834	0.9506
V39	108.0481	800.4928	0.2713	0.6882	0.9540

The high values of Cronbach's coefficients signal that the variables that comprised the technological development construct were selected appropriately.

4.6. FACTOR ANALYSIS

When working with variable data that are to be analyzed using Factor Analysis (FA), Hair *et al.* (2005, p. 94) teach us that there are basic numbers for carrying out certain multivariate data analysis techniques. This being so, in this practical case we can see that the mathematical relationship between the number of valid observations, considering at the same time the variables maintained after analysis of the missing values, for the total number of variables involved, is 104/23, which gives us the number

4.52, which is very good and close to the 5.00 required by eminent researchers. The ideal is that there should be ten observations (HAIR *et al.*, 2005, p. 98) per variable, but this rarely happens in practice, above all in exploratory research, which involves obtaining primary numbers by means of interviews with managers and directors, either from Brazilian companies or from multinational/transnational companies.

The basic hypothesis of this technique lies in the existence of correlations between the variables, the cause of which arises from the common factors shared between them. With this technique we analyze the interdependence between the variables from the correlation matrix. This technique makes it possible to capture factors that are not directly observable from the known variables taken from the field data collected. Johnson and Wichern (1992, p. 396) explain that in common factor analysis the variables are grouped as a function of their correlations, signifying that the variables that go to make up a particular factor must be highly correlated between themselves and weakly correlated with the variables that comprise the other factor.

<u>Correlation matrix</u> **–** to be pertinent the use of factor analysis it is needed to establish the existence of significant correlations between pairs of variables, thus justifying the premiss that they do, in fact, have factors in common.

Table 7 gives the correlations of the variables in the study.

Table 7: Correlations

Var.	V3	V4	V5	V6	V7	V8	V9	V10	V11	V13	V14	V17	V18	V21	V22	V25	V29	V30	V31	V32	V34	V35	V39
V3	1.00	0.80	0.51	0.54	0.65	0.68	0.60	0.68	0.59	0.62	0.47	0.34	0.51	0.36	0.69	0.30	0.27	0.27	0.36	0.48	0.46	0.37	0.14
V4	0.80	1.00	0.64	0.58	0.86	0.76	0.69	0.73	0.67	0.61	0.53	0.41	0.50	0.47	0.69	0.48	0.41	0.31	0.50	0.46	0.39	0.31	0.11
V5	0.51	0.64	1.00	0.64	0.67	0.56	0.71	0.62	0.68	0.64	0.55	0.39	0.50	0.37	0.43	0.38	0.53	0.30	0.48	0.29	0.15	0.17	-0.04
V6	0.54	0.58	0.64	1.00	0.66	0.56	0.56	0.56	0.64	0.66	0.59	0.37	0.47	0.41	0.43	0.42	0.52	0.38	0.49	0.33	0.25	0.24	0.04
V7	0.65	0.86	0.67	0.66	1.00	0.77	0.79	0.74	0.73	0.66	0.57	0.44	0.45	0.57	0.60	0.48	0.41	0.36	0.43	0.53	0.42	0.41	0.22
V8	0.68	0.76	0.56	0.56	0.77	1.00	0.75	0.78	0.73	0.64	0.56	0.34	0.51	0.50	0.65	0.53	0.33	0.37	0.43	0.52	0.34	0.47	0.13
V9	0.60	0.69	0.71	0.56	0.79	0.75	1.00	0.73	0.73	0.63	0.57	0.46	0.45	0.45	0.62	0.47	0.35	0.30	0.39	0.49	0.22	0.41	0.10
V10	0.68	0.73	0.62	0.56	0.74	0.78	0.73	1.00	0.79	0.69	0.57	0.39	0.55	0.41	0.70	0.58	0.41	0.36	0.45	0.51	0.36	0.42	0.11
V11	0.59	0.67	0.68	0.64	0.73	0.73	0.73	0.79	1.00	0.63	0.54	0.51	0.59	0.34	0.59	0.56	0.49	0.37	0.57	0.57	0.40	0.50	0.22
V13	0.62	0.61	0.64	0.66	0.66	0.64	0.63	0.69	0.63	1.00	0.80	0.44	0.67	0.61	0.66	0.58	0.45	0.52	0.47	0.48	0.34	0.40	0.18
V14	0.47	0.53	0.55	0.59	0.57	0.56	0.57	0.57	0.54	0.80	1.00	0.41	0.53	0.70	0.58	0.54	0.48	0.49	0.46	0.45	0.28	0.37	0.15
V17	0.34	0.41	0.39	0.37	0.44	0.34	0.46	0.39	0.51	0.44	0.41	1.00	0.45	0.39	0.45	0.29	0.50	0.20	0.37	0.42	0.35	0.33	0.29
V18	0.51	0.50	0.50	0.47	0.45	0.51	0.45	0.55	0.59	0.67	0.53	0.45	1.00	0.45	0.65	0.54	0.43	0.56	0.61	0.45	0.21	0.36	0.03
V21	0.36	0.47	0.37	0.41	0.57	0.50	0.45	0.41	0.34	0.61	0.70	0.39	0.45	1.00	0.57	0.52	0.37	0.53	0.37	0.52	0.34	0.39	0.28
V22	0.69	0.69	0.43	0.43	0.60	0.65	0.62	0.70	0.59	0.66	0.58	0.45	0.65	0.57	1.00	0.57	0.47	0.40	0.51	0.51	0.37	0.41	0.15
V25	0.30	0.48	0.38	0.42	0.48	0.53	0.47	0.58	0.56	0.58	0.54	0.29	0.54	0.52	0.57	1.00	0.43	0.55	0.54	0.39	0.30	0.37	0.21
V29	0.27	0.41	0.53	0.52	0.41	0.33	0.35	0.41	0.49	0.45	0.48	0.50	0.43	0.37	0.47	0.43	1.00	0.38	0.63	0.24	0.24	0.10	0.06
V30	0.27	0.31	0.30	0.38	0.36	0.37	0.30	0.36	0.37	0.52	0.49	0.20	0.56	0.53	0.40	0.55	0.38	1.00	0.62	0.61	0.13	0.13	0.32
V31	0.36	0.50	0.48	0.49	0.43	0.43	0.39	0.45	0.57	0.47	0.46	0.37	0.61	0.37	0.51	0.54	0.63	0.62	1.00	0.46	0.23	0.05	0.10
V32	0.48	0.46	0.29	0.33	0.53	0.52	0.49	0.51	0.57	0.48	0.45	0.42	0.45	0.52	0.51	0.39	0.24	0.61	0.46	1.00	0.39	0.49	0.49
V34	0.46	0.39	0.15	0.25	0.42	0.34	0.22	0.36	0.40	0.34	0.28	0.35	0.21	0.34	0.37	0.30	0.24	0.13	0.23	0.39	1.00	0.52	0.63
V35	0.37	0.31	0.17	0.24	0.41	0.47	0.41	0.42	0.50	0.40	0.37	0.33	0.36	0.39	0.41	0.37	0.10	0.13	0.05	0.49	0.52	1.00	0.46
V39	0.14	0.11	-0.04	0.04	0.22	0.13	0.10	0.11	0.22	0.18	0.15	0.29	0.03	0.28	0.15	0.21	0.06	0.32	0.10	0.49	0.63	0.46	1.00

Table 7 reveals the existence of various pairs of variables with high correlation. This fact reinforces the premiss of the existence of factors shared by the variables and the pertinence of applying factor analysis.

Kaiser - Meyer - Olkin (KMO) Measure – this index compares the total number of correlations between pairs of variables, with the partial correlations between them. The closer this measure is to 1, the greater the quality of the factor analysis. KAISER (1974) classifies bands of this measure as: equal to or greater than 0.9 – excellent; equal to, or greater than 0.8, and less than 0.9 – reliable; equal to or greater than 0.7, and less than 0.8 – regular; equal to, or greater than 0.6, and less than 0.7 – mediocre; equal to, or greater than 0.5, and less than 0.6 – worthless; and less than 0.5 – unacceptable.

Bartlett's sphericity test – this allows the following hypothesis to be tested:

H_0: the correlation matrix is an identity matrix

This hypothesis should be rejected in order to reinforce the appropriate nature of the use of factor analysis.

Table 8 shows the KMO measure and Bartlett's test.

Table 8: KMO Measure and Bartlett's Test

Measure of the adequacy of the sample, according to Kaiser-Meyer-Olkin (K-M-O) criteria		0.869
Bartlett's sphericity test	Approx Chi-squared.	2082.049
	DF (degrees of freedom)	253
	Significance level	0.000

The KMO measure proved to be suitable. As expected the hypothesis formulated in Bartlett's test was rejected, thus endorsing the existence of factors underlying the variables.

Communalities – each of the original variables has an associated variance that reflects the differences between the sample elements. The communality of each variable corresponds to the percentage of its variance, which is accounted for the factors obtained from the factor analysis.

It is obtained by the sum of the squares of the factor loadings for each variable. The greater the value of the communality, the more satisfactory was the substitution of a certain variable by the set of factors.

Table 9 shows the communalities we obtained. The results are satisfactory. The biggest and smallest results relate to variables V30 and V25, respectively.

Table 9: Communalities

V3	0.688
V4	0.783
V5	0.734
V6	0.617
V7	0.798
V8	0.797
V9	0.750
V10	0.777
V11	0.765
V13	0.739
V14	0.645
V17	0.620
V18	0.620
V21	0.619
V22	0.654
V25	0.591
V29	0.785
V30	0.805
V31	0.731
V32	0.653
V34	0.733
V35	0.661
V39	0.804

Eigenvalues – correspond to the total variance accounted in each factor. Eigenvalues reflect the % variance that each factor is capable of explaining in relation to the variance of the original variables. They allow us to establish stopping rules in accordance with their levels, in the definition of the number of factors for the technique.

Percentage variance accounted for each factor (before and after factor rotation) and total variance accounted for the factors – the percentage of variance accounted for each factor is a synthesis measurement, indicating how much of the total variance of the original variables the factor represents.

Using the main components' method for factor analysis and a minimum *eigenvalue* equal to 1 we obtained 4 factors. Table 10 shows the percentage of variance per factor and the accumulated total.

Table 10: Accounted Variance

	Before rotation			After rotation		
Components	*Eigenvalue*	Variance %	Accrued %	*Eigenvalue*	Variance %	Accumulated %
1	11.555	50.237	50.237	7.133	31.012	31.012
2	2.038	8.861	59.098	4.099	17.822	48.834
3	1.696	7.373	66.471	2.692	11.705	60.539
4	1.082	4.705	71.176	2.446	10.637	71.176

From what we can gather from analyzing Table 10, 71.176% of the total variance of the variables is accounted for just 4 factors.

Factor loadings and naming the factors – they reflect the importance of the factors in the composition of each variable and, reciprocally, the weigh of the variables in each factor.

Table 11 shows the allocation of the variables in the factors, according to the factor loadings.

Table 11: Matrix of Rotated Components

Variables	Factors			
	1	2	3	4
V3	0.781	0.151	0.225	7.335E-02
V4	0.821	0.204	0.137	0.219
V5	0.685	0.173	-0.127	0.467
V6	0.595	0.260	-0.014	0.442
V7	0.802	0.232	0.234	0.214
V8	0.817	0.319	0.163	3.219E-02
V9	0.817	0.214	0.102	0.165
V10	0.803	0.297	0.142	0.155
V11	0.705	0.240	0.253	0.382
V13	0.615	0.545	0.125	0.219
V14	0.491	0.588	9.765E-02	0.220
V17	0.287	9.478E-02	0.402	0.606
V18	0.418	0.601	2.950E-02	0.290
V21	0.318	0.662	0.274	6.408E-02
V22	0.612	0.460	0.203	0.165
V25	0.342	0.649	0.144	0.179
V29	0.217	0.285	2.065E-02	0.811
V30	5.763E-02	0.872	9.242E-02	0.182
V31	0.222	0.560	-0.010	0.607
V32	0.325	0.536	0.508	5.196E-02
V34	0.245	2.760E-02	0.797	0.192
V35	0.400	0.172	0.670	-0.151
V39	-0.102	0.182	0.870	5.898E-02

Naming the factors:

a) Intelligent Information Technology Factor (IITF), which covers the variables V3 to V11, V13 and V22, because this factor has components that essentially have to do with computing, such as technology, information, collection, data storage, transforming data into information and, above all, the relationship between technology, information and telecommunications, the heart of the digital era. It is a significant competitive differential.

b) Internal Strategic and Productive Factor (ISPF), which covers the variable V14, V18, V21, V25, V30 and V32, because it involves the internal strategic positioning of the organization, coupled with methods, tools and methodologies for maximizing the productivity of the machinery and equipment, as a whole.

c) Momentary-structural Factor (MSF), which covers the variables V34, V35 and V39, in which the need to focus on a particular problem or problems in a masterful way predominates, in addition to modifying the structure of companies, making them lighter, more agile, in such a way as to be able to face up to global competition.

d) External Strategic Factor (ESF), which covers the variables V17, V29 and V31, not only as far as the traditional strategic plan, proposed by Ansoff and others, is concerned, but also reverse strategic planning, with paradigm change, as proposed by C. K. Prahalad.

4.7. TECHNOLOGICAL LEVEL

In this section we intend to determine the technological level of industrial companies. This is a theme, the solution of which is complex, because we have to analyze, among other considerations, the amount of fixed assets the companies have, if the machinery and/or equipment is accompanying global technological development, if there is a relationship between fixed assets and total capital, here understood as being the sum of the fixed assets plus variable assets, if the company has a certain level of product launches in the market and if it trains and develops its employees well.

To calculate the Technological Level and subsequent classification of the companies we applied the following formula (FACHEL, 1976, p. 76-77):

$$I_i = \sum_{j=1}^{4} F_{ij}.P_j$$

Formula 1

where:

I_i = Global Technological Level Index, according to the i^{th} person interviewed, i varies from 1 to 104

F_{ij} = Factorial score for the i^{th} person interviewed and the j^{th} factor;

P_j = Percentage of Variance Accounted for Factor j before and after rotation, without dividing by 100.

We calculated the average of the index for each company, based on the factorial scores after rotation of the axes using the Varimax method. The data were then standardized by dividing each average by the maximum observed value. The maximum average obtained was 37.96, relative to Siemens.

Table 12 gives the indices of the calculated technological level for the companies we researched.

Table 12: Technological Level Index

3M	18.17
Alcoa	6.22
Bunge	-95.30
Colgate-Palmolive	79.37
Daimler-Chrysler	43.91
Diagnósticos das Américas	44.09
Engemix	-303.08
Festo	-12.14
Galvanoplastia Mauá	-170.07
Lanxess	0.79
Magnetti-Marelli	-12.18
Makita	0.00
Microsiga	-99.92
Multibrás	60.37
Pichinin	0.00
Romi	27.71
Sanches-Blanes	-176.38
Siemens	100.00
Sig-Simonazzi	-6.07
Usimac	58.86
Votoran - Cimentos	-118.96
Votorantim Metais	0.00

As can be seen in Table 12, Siemens, Colgate-Palmolive, Multibrás, Usimac, Diagnósticos das Américas and Daimler-Chrysler stand out as far as their technological level is concerned.

5. CONCLUSION

In the light of the theoretical point of reference presented, in this work we selected those variables in which we were interested. Furthermore, from the results presented important information can be highlighted:

a) The variables most used regarding the technological development of industrial companies, according to the arithmetic mean, are: V14. Total Quality Control (TQC), V13. Statistical Quality Control (SQC), V3. *Computer - Aided Design (CAD)*, V21. Total Quality Management (TQM), V8. *Computer - Aided Process Planning (CAPP)*, V4. *Computer - Aided Engineering (CAE)*, V23. *Just-in-Case (JIC)*, V22. *Global Sourcing (GS)* and V7. *Computer - Aided Manufacturing (CAM)*.

b) From the calculations using Cronbach's alpha coefficient, we can see that the dimension relative to technological level is reliable, in other words, the model adapted for this study proved to be consistent in this dimension.

The high levels of reliability reveal the consistency of the construct and that the right variables were selected.

c) Finally, this study presented the technological level of the companies we researched and indicated that some companies in the industrial sector are lagging behind in their actions as far as technological development is concerned, and this aspect is extremely important in an increasingly competitive scenario.

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