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ABSTRACT

Information Technology (IT) diffusion is a central theme of the new economy and is evidenced through a process, named Informatization, which permeates our society and businesses. Relative to businesses, managers have a need for instruments to evaluate the organizational use of IT and inform them about its possibilities. This paper presents a tool for evaluating the organizational use of IT based on the measurement of the Informatization Level of companies. Four evaluation dimensions are considered: IT assets; IT organizational use; IT governance; and IT impacts. The tool was built starting with 345 survey questions that were summarized to 66 indicators. A sample of 830 industrial companies was covered and structural equation modeling was employed to develop and validate the model. It achieved requirements of reliability and internal validity and showed external validity, as the hypothesis of being related to size and of not being related to IT investment were confirmed.

Keywords

IS Evaluation; Informatization; Computerization Level; Organizational Use of IT

INTRODUCTION

The term informatization is employed to represent the use of information technology resources at the organizations. Weissbach (2003) defines informatization as being the process of gradual and increasing application of *"planned and systematic use of IT penetrating the organization's functions*" (p. 676). As pointed out by Lim (2001), the evaluation of an organization's *informatization level* (IL) is an important managerial concern. The author also points out the difficulties associated with this evaluation, stating that "*this is not a simple problem because informatization includes many intangible factors such as the quality of information and the organization's culture*" (p. 145). The purpose of evaluating a company's informatization level is to provide information for the organization to improve its informatization level. It is also a means of benchmarking the efficacy and efficiency of IT investments in order to set up the baseline for improvement.

The present work proposes a measurement instrument for the informatization level of companies. The development of this measurement was based on the principle that IT results in companies are not obtained merely through investments and the implementation of systems, but rather through its proper use in business processes. During the development of the evaluation tool we tried to cover all aspects involved in the informatization process and to make this tool become an instrument for self-evaluation and learning, thereby allowing business managers to understand the possibilities offered by the use of IT and the aspects involved in the informatization process. This work extends the informatization dimensions proposed by Lim (2001), using the process-based view of the IT business value framework proposed by Soh and Markus (1995) and the concept of "information systems coverage", proposed by Ravarini et al. (2002).This study was conducted together with the Federation of Industries of the State of São Paulo (FIESP), which represents the trade associations of the controllers of industrial companies in this state, which is the most industrialized of Brazil.

RESEARCH MODEL

Informatization can be defined as the managed process by which an organization continuously expands its IT assets and extends and deepens their appropriate use, aimed at improving the effectiveness and performance of its activities and processes. The four dimensions proposed for the informatization level in organizations are: (1) **IT assets**, related to both tangible and intangible IT resources; (2) **IT organizational use**, related to the extent and intensity of IT use in the organization; (3) **IT management**, related to the management of IT resources, the management of its use and the planning

and development of IT resources aligned with the organization's businesses; (4) **IT impacts**, related to effectiveness and performance benefits for organizational activities and processes, achieved through the use of IT. The dimensions appear in the research model shown in figure 1.

IT expenditures correspond to the sum of investments in IT and expenses with IT. They are a necessary although insufficient condition, for achieving certain levels of informatization, as indicated by the dotted arrow to the left of the figure. A better informatization level can contribute to the improvement of the organization's performance, although not necessarily so, as indicated by the dotted arrow to the right. The operational characteristics of the enterprise (for example, its size and the sector in which it operates) appear mediating IT expenditures and the informatization level in the organization's performance. The characteristics of IT management also interfere in the conversion of IT expenditures into an informatization level. The dimensions "IT organizational use", "IT management" and "IT assets" work in combination, for the obtainment of "IT organizational impacts". The set of these four dimensions comprise the measurement structure proposed for the informatization level.

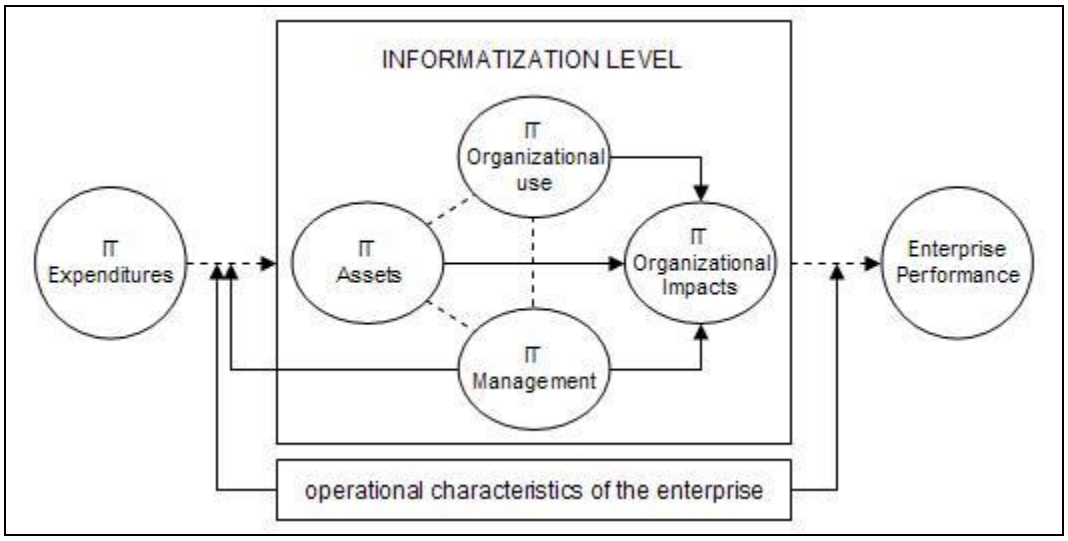

Figure 1 - Research Model

RESEARCH METHODOLOGY

The research gathered data using an electronic questionnaire as a Web survey. Each of the companies invited to take part in it received an invitation via e-mail and a printed letter containing information on the survey and the password to access the questionnaire. The questionnaire remained available for the respondents from December 16, 2003 to February 10, 2004 and was divided into 10 modules with a total of 316 questions.

The questionnaire employed is the refinement of two versions used in previous editions of the research, conducted in 2000 and 2002. In this process, questions considered inadequate or which were misunderstood were dropped. Although the final questionnaire may be considered large, it was developed to be answered by the business managers (one for each area) guided by the IT manager. Also, the Web site was developed to allow the respondents to save their answers and continue later. Finally, the main idea of the questionnaire was to offer a tool of self-evaluation to the companies, so it was expected that they would answer it completely and adequately. The complete version of the questionnaire can be obtained upon request to the authors.

After data collection, an analysis of the variables in each dimension was conducted, with the objective of preparing the data and verifying the adequacy of the several variables associated to informatization. The initial dimensions proposed for the informatization level and its indicators are shown on table 1. This analysis followed the steps proposed by Hair et al. (1998), which led to the elimination of univariate and multivariate outliers, analysis of the shape of the distributions and variable transformations seeking to follow the normal distribution. After this preparation, an exploratory factor analysis was conducted to verify the adequacy of the variables to the dimension proposed and identify the factors present. The reliability of the factors obtained was tested on the basis of the Cronbach Alpha values calculated for each factor.

The variables considered adequate for each dimension were then introduced in the initial model of the informatization level, and those that had no relation with the others were dropped. The model was then operationalized using the selected variables

and factors (sub dimensions). Finally, the model was tested by means of confirmatory factorial analysis (CFA) by applying Structural Equation Modeling (SEM). The results obtained allowed an analysis of the adequacy of the variables to the proposed structure as a basis for changes in the model initially proposed. The χ^2/df, TLI, NFI and CFI indexes were used to verify the general fit of the model, and the χ^2/df and PNFI indexes were used to compare the alternative models proposed. SEM modeling was performed using the AMOS 4 software.

Dimension	*Sub dimensions*	*Components of Subdimensions*	*Questions, Indicators and References*
IT Assets	Infra structure (INFRA)	Conectivity: Internal (INTCON) External (EXTCON) Infrastrucure Services (SERVS)	Indicators like # of PCs / Employee, # of PCs connected, Internet connection speed, security strategies (Lim, 2001), internal connectivity, external connectivity and infrastructure services (Weill and Broadbent, 1998).
	Applications Portfolio (PORTFL)	Technical Quality (TECQUAL) Integration (INTEGR) Adequacy (ADEQ)	Technical quality of systems in each area of application (sales, marketing, production, procurement, management, finance and other applications of IT), measured along a scale going from use of spreadsheets to fully-integrated ERP systems for each area of application. Likert-scale questions assessing respondents' perception of the degree of adequacy of these systems to the activities they support.
	People	Participation and knowledge: Executives (EXPART) Users (USPART)	Likert-scale questions assessing the respondents' perception about the degree of participation of users and executives in IT planning and their knowledge about IT and systems in use in the company.
IT Organizational Use (ORGUSE)	Extension (EXTENS)		Using the concept of "information systems coverage" (Ravarini et al., 2002), several activities were defined for each area of application and the extension of use was measured considering the percentage of these activities held with information systems support.
	Dependency (DEPEND)		Likert-scale questions assessing the degree of dependency of the enterprise on the information systems in each of the considered activities.
IT Management	IT Department Infrastructure (ITDEPIN)		Indicators like # of IT personnel / # of PCs, existence of an IT area, existence of an IT manager, # of IT activities executed (Lim, 2001).
	IT Planning & Control (PLANCTL)		Likert-scale questions assessing the respondents' perception about IT strategic alignment and control of IT activities.
IT Impacts (IMPACS)	IT Impacts: traditional applications (IMTRAD) other applications (IMOTH)		Likert-scale questions assessing IT impacts on the organization (Mahmood and Soon, 1991). The questions were focused on the following items: sales increase, cost reduction, quality increase of products and services, delivery time reduction and impacts on processes specific to each area of application and to the group of other applications (Internet, CRM, SCM, CAD, BI).

Table 1 - Informatization Level dimensions

Some hypotheses were tested to verify the informatization level variation in relation to the company's operational characteristics. The characteristics used in the tests were not employed for constructing the measurement. Upon confirmation of these hypotheses we also expect to obtain indications as to the external validity of the companies' informatization measurement.

(H1) A significant positive relationship exists between IL and company size, measured in terms of number of employees or invoicing. That is, to companies with larger number of employees or invoicing will correspond a higher informatization level. As pointed out by Teo and Wong (1998), a higher level of IT use in larger companies is expected in view of the greater quantity of resources that can be invested. Furthermore, the use of IT is a necessity in larger firms in order to manage the increasing complexity of their operations.

(H2) A significant positive relationship exists between IL and the company's business process complexity. When the business processes dictate greater information needs, due to their complexity, there is also greater effort in the process of converting IT investments with direct impact on the informatization level.

(H3) No significant relationship exists between IL and IT investment level. In principle there could exists factors associated to the company that restrain the conversion of investments to a higher informatization level.

(H4) A significant positive relationship exists between company size and the conversion capacity of IT expenditures into a greater IL. Larger companies convert their IT investments more efficiently, spending less "monetary units" per "informatization unit". In these companies the IT management processes and the involvement and participation of executives and users are in principle more developed, and considering that these are the main components of the "conversion factor" proposed by Weill (1992), one expects that they will obtain greater gains from their IT investments.

RESEARCH RESULTS

Sample of Companies

The invitation to participate at the survey was sent to 17,211 industrial companies registered at FIESP, divided into 519 large (3.0%), 2,845 medium (16.5%), 12,303 small (71.5%) and 1,545 micro-companies (9.0%). The size of the responding company was based on the number of employees: 1 to 9 for micro companies; 10 to 99 for small; 100 to 499 for medium; and above 500 for large companies. Until the end of the data gathering period the site was accessed 1,621 times. 1,330 companies fully or partially completed at least one of the modules of the questionnaire, and 830 completed it in a way considered sufficient and were included in the sample, as detailed on table 2.

Size	*FIESP Registration*	*%*	*Final Sample*	*%*	*Sample for IL*	*%*
Micro (up to 10 employees)	1,518	8.8%	76	5.7%	30	3.6%
Small (11 to 99 employees)	12,316	71.5%	941	70.8%	555	66.9%
Medium (100 to 499 employees)	2,853	16.6%	222	16.7%	168	20.2%
Large (500 or more employees)	524	3.1%	91	6.8%	77	9.3%
Total	17,211	100.0%	1,330		830	
% of the FIESP Register			7.7%		4.8%	

Table 2 - Distribution of companies in the sample per size

In this sample the overall percentage of missing values is 17.3%. Kline (1998) classifies levels of up to 10% of missing values as being low, whereas levels above 30% are considered high. The FIML method (*Full Information Maximum Likelihood*) available in the AMOS software was used to estimate the model. According to Arbuckle and Wothke (1999), the method is sound even when the missing data is not completely random. The size of the sample used was within the minimum limit recommended by Hair et al. (1998) of five cases per estimated parameter (830 cases / 165 free parameters).

Informatization Level Model

After the process of transforming the variables and the exploratory factor analysis, the initial model for the informatization level was prepared. It consisted of 24 first order factors, 6 second order factors (sub-dimensions of IL) and 71 indicator variables developed on the basis of the 316 questions of the questionnaire. The model was then perfected adopting the steps described by Hair et. al. (1998): (1) verification of the existence of *offending estimates* and adoption of corrective measures; (2) evaluation of general adjustment measures for the model; (3) evaluation of the measurement model and structural model and re-specification of the model if necessary; (4) comparison with alternative models and re-specification if necessary.

The final model that emerged from the Confirmatory Factor Analysis (CFA) is shown at figure 2 together with the factorial loads obtained for the components. In relation to the initial model the following changes were made, suggested by the modification indexes of SEM: the IT Management dimension was associated to the people subdimension, forming a dimension that was named IT Governance (ITGOVRN); the adequacy subdimension was incorporated into the IT organizational use dimension; the indicators associated to other applications were gathered in a single subdimension called extent of other applications used (EXOTH), placed under the organizational use dimension; and finally the IT department infrastructure component was added to the Infrastructure dimension. Besides this, to avoid excessive complexity and so that

the model contained only second order dimensions, the sub dimensions infrastructure (INFRA) and applications portfolio (PORTFL) were placed in the model at the same level as the main dimensions.

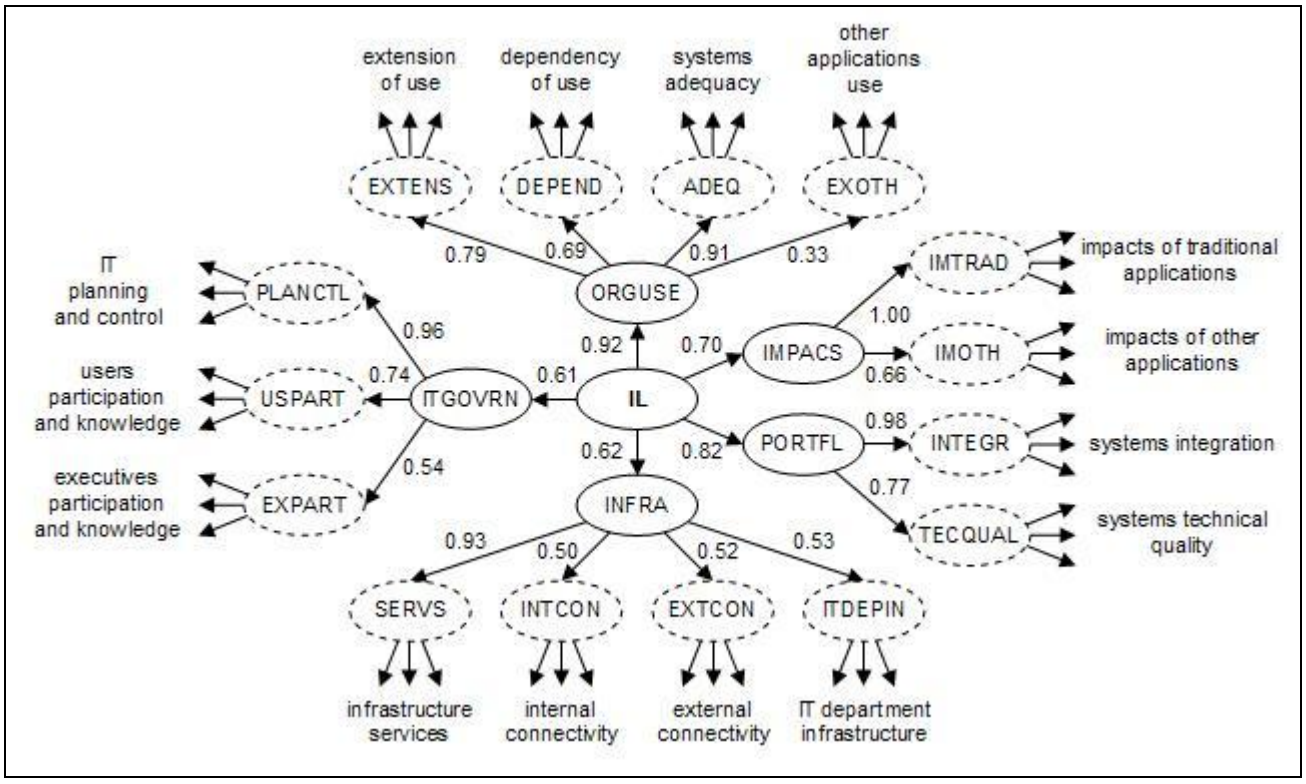

Figure 2 - CFA Model for the Informatization Level with standardized factor loadings

Table 3 shows the goodness-of-fit indexes of the initial and final model, and table 4 the reliability values of the first and second order factors (subdimensions) calculated according to Hair et al. (1998). These authors establish a minimum value of 0.7 for reliability and 50% for explained variance. For the third order factor (IL) a reliability of 0.836 and an explained variance of 56.8% were obtained.

	Initial Model	*Final Model*
Number of variables	71	66
Number of dimensions	5	5
Number of sub dimensions	17	15
χ^2/df (<= 5.0)	5.705	4.486
NFI (>= 0.9)	0.898	0.924
TLI (>= 0.9)	0.908	0.936
CFI (>= 0.9)	0.914	0.940
PNFI	0.840	0.863

Table 3 - Goodness-of-fit indexes

The general fit indexes showed adequate values within the specified limits. All constructs showed acceptable reliability with only one very close to the limit and 5 of them with explained variance below 50%. Two of them showed explained variance below 40% (the SERVS factor - IT infrastructure services and the PLANCTL factor - planning and control of the IT area). This may suggest the need to reassess the variables employed for these constructs. All the calculated factorial loads also showed statistical significance at 1% level. Therefore the modified model was considered adequate and used as a base for the calculation of the factorial scores for IL and its dimensions.

Factorial Load	*2nd order factor*	*Reliability*	*Explained Variance*	*Factorial Load*	*1st order factor*	*Reliability*	*Explained Variance*
0.62	INFRA	0.723	**41.4%**	0.93	SERVS	**0.684**	**36.7%**
				0.50	INTCON	0.774	53.6%
				0.52	EXTCON	0.763	53.6%
				0.53	ITDEPIN	0.907	66.6%
0.61	ITGOVRN	0.804	59.0%	0.96	PLANCTL	0.730	**35.9%**
				0.74	USPART	0.810	46.6%
				0.54	EXPART	0.867	57.0%
0.92	ORGUSE	0.792	51.5%	0.79	EXTENS	0.764	**44.9%**
				0.69	DEPEND	0.895	68.2%
				0.91	ADEQ	0.872	63.0%
				0.33	EXOTH	0.880	67.5%
0.70	IMPACS	0.830	69.2%	1.00	IMTRAD	0.938	65.5%
				0.66	IMOTH	0.882	65.8%
0.82	PORTFL	0.872	77.5%	0.98	INTEGR	0.882	65.2%
				0.77	TECQUAL	0.933	77.6%

Table 4 - Reliability and explained variance for 1st and 2nd order factors

Factorial Scores for IL and its Dimensions

The results obtained were used to calculate the factorial scores for IL and its dimensions, which were converted to the scale [0, 1] so as to facilitate its comparison by means of the descriptive statistics shown in Table 5. This table also shows the p-values of ANOVA tests performed to verify the significance of the difference between different company sizes. The ANOVA tests for both the scores for IL and the component dimensions showed significant differences in all dimensions between all sizes, except for ITGOVRN, which showed no difference between medium and large companies. Therefore the H1 hypothesis, which states that a significant positive relationship exists between the IL and the company size, was considered confirmed.

Variable	*Statistics*	*Micro*	*Small*	*Medium*	*Large*	*General*	*p-value ANOVA*
IL	$\overline{X}$	0.29	0.46	0.60	0.72	0.51	< 0.01
	SD	0.20	0.20	0.21	0.17	0.22	
IMPACS	$\overline{X}$	0.28	0.39	0.47	0.57	0.42	< 0.01
	SD	0.24	0.23	0.23	0.22	0.24	
ORGUSE	$\overline{X}$	0.28	0.46	0.59	0.72	0.50	< 0.01
	SD	0.20	0.20	0.21	0.16	0.22	
PORTFL	$\overline{X}$	0.31	0.48	0.62	0.73	0.52	< 0.01
	SD	0.21	0.21	0.22	0.17	0.23	
ITGOVRN	$\overline{X}$	0.32	0.48	0.56	0.64	0.50	< 0.01
	SD	0.30	0.28	0.29	0.28	0.29	
INFRA	$\overline{X}$	0.35	0.52	0.68	0.80	0.57	< 0.01
	SD	0.17	0.18	0.18	0.17	0.21	

Table 5 - Statistics related to the factorial scores of IL and its dimensions

Relation of IL with Operational Characteristics

The total and partial correlations controlling for the total number of employees, were calculated to verify the relation between IL and some of the operational characteristics of the companies. The results are shown on table 6. Considering that IL increases with the size of the company, the partial correlation allows one to check whether IL is actually related to the characteristics shown, discounting the effect of its increase with size. The number of companies considered in the computation of the correlations is also displayed in the table, since not every company informed the characteristics considered.

Variable	*Total Correlation*			*Partial Correlation controlling the number of employees*		
	r	*p*	*N*	*r*	*p*	*N*
Number of employees	0.488	< 0.01	663	---	---	---
Number of PCs	0.547	< 0.01	814	0.285	< 0.01	660
Number of users	0.595	< 0.01	651	0.395	< 0.01	630
Invoicing in US$ in 2003	0.505	< 0.01	712	0.219	< 0.01	595
Invoicing per employee in 2003	0.377	< 0.01	580	0.272	< 0.01	577
Number of types of products sold	0.306	< 0.01	707	0.191	< 0.01	594
Number of customers	0.284	< 0.01	728	0.144	< 0.01	611
Number of raw materials used	0.278	< 0.01	686	0.154	< 0.01	568
Average entries in accounts receivable	0.447	< 0.01	632	0.200	< 0.01	554

Table 6 - Correlations between IL and operational characteristics of the companies

All the variables show statistically significant correlations with IL, even if one eliminates the effect of the company's size. This indicates that a higher informatization level is also related to certain operational characteristics of the companies, such as the number of customers, number of types of products sold, number of raw materials used, and number of operations performed in the administrative area (represented by entries in accounts receivable). Likewise, it is important to consider the significant correlation with invoicing per employee, since this represents a possible measure of the company's "productivity". The conclusion is that the companies with greater productivity, discounting the effect of their size, are associated with a higher informatization level. Therefore the H2 hypothesis, which states that a significant positive relationship exists between the IL and the company's business process complexity, was considered confirmed.

Relation of IL with IT Investments

The total and partial correlations, discounting the effect of company size, were calculated to verify the relation between IL and the variables associated to IT expenditures in the companies, consisting of investments and expenses. The results obtained are shown on table 7.

Variable *(2001 to 2003 average values)*	*Total Correlation*			*Partial Correlation controlling the number of employees*		
	r	*p*	*N*	*r*	*p*	*N*
Average IT expenditure in US$	0.192	< 0.01	388	0.396	< 0.01	307
Average IT investment in US$	0.167	< 0.01	388	0.287	< 0.01	307
Average IT expense in US$	0.199	< 0.01	388	0.404	< 0.01	307
Average IT expenditure as a % of invoicing	**0.057**	**0.271**	**373**	**0.144**	**0.011**	**307**
Average IT investment as a % of invoicing	**-0.104**	**0.046**	**373**	**0.024**	**0.680**	**307**
Average IT expense as a % of invoicing	0.310	< 0.01	350	0.216	< 0.01	307

Table 7 - Correlations between IL and the variables pertinent to IT expenditures

The expenditures, expenses and investments in absolute values revealed a relation with IL, even removing the effect of company size. This result is contrary to the idea initially proposed that greater investments do not necessarily result in a higher informatization level. On the other hand, when taken as a percentage of invoicing, they do not show a correlation with IL, considering that, with regard to expenses, a higher IL in principle always corresponds to greater expenses for maintaining

the IT area. Therefore the H3 hypothesis, which states that no significant relationship exists between the IL and IT investment level, was considered only partially supported.

Relation of IL with the "IT Conversion Factor"

Two indicators dividing the IL by the amounts invested were calculated so as to analyze the H4 hypothesis, which specifies that the larger companies convert their IT investments more efficiently. The objective was to enable an analysis of how much informatization the company manages to gain according to the amount invested. The "absolute conversion factor" variable (FCONVABS) was calculated dividing IL by the average amount of investments in dollars and the "relative conversion factor" variable (FCONVREL) was calculated dividing IL by the average investments as a percentage of invoicing. To make the comparison straightforward, the two variables were transformed so as to vary within the interval [0, 1] and the averages of the variables per company size are shown on table 8. The data shows that small companies have a greater FCONVABS which suggests that it is cheaper for them to reach the same IL as greater companies. But they also have a lower FCONVREL which suggests that the investment may be difficult because they invest proportionally more of their invoicing to reach the same level.

Size	*Absolute conversion factor FCONVABS*	*Relative conversion factor FCONVREL*
Micro	0.231	0.066
Small	0.122	0.074
Medium	0.034	0.168
Large	0.006	0.161
p-value ANOVA	<0.01	<0.01

Table 8 - Conversion factors per company size

The drop observed in FCONVABS as the company size increases can be justified by two possible reasons. First, it is possible that the informatization of larger companies has higher costs due to the sophistication of the technologies used. Second, one must consider that the same task involves much larger volumes in the larger companies, and consequently the IT costs are also higher. These reasons also justify the correlation pointed out in the previous item between IT investments in absolute values and the IL, and do not invalidate the H4 hypothesis that the larger companies convert their IT investments more efficiently. However, one can argue that as of a certain point of informatization it becomes harder to take the subsequent steps of this process (as are eventually the steps of CRM and SCM systems implementation and use) and, therefore, increments in the conversion capacity would naturally tend to be increasingly limited. This situation would affect precisely the larger companies that have already reached higher informatization levels. This argument suggests that a stage of deceleration of the increase in conversion capacity may be reached based on the size of the company, which would tend not to support the H4 hypothesis.

Conversely, the increase of FCONVREL observed in larger companies can be justified by a greater conversion efficiency of IT investments into effective informatization. The apparent leveling out revealed in the table data for the larger companies may reflect the effect of greater technological sophistication, which then demands a proportionally greater allocation of the company's invoicing to IT investments, despite the greater conversion capacity. This interpretation supports the H4 hypothesis. However, another interpretation as to why the table data levels out is the possible deceleration of the conversion capacity, due to greater difficulty in taking new steps of the informatization possibilities in larger companies. Both the IL and the IT investments would tend to stabilize and therefore the H4 hypothesis would not longer be supported. Considering the preceding discussion it seems fair to conclude that the H4 hypothesis, which states that a significant positive relationship exists between company size and the conversion capacity of IT expenditures into a greater IL is only partially supported.

CONCLUSIONS

The development of the IL measurement was performed in such a way as to include the aspects considered relevant and that involve the intensity and quality of IT use in the companies. The development of the measurement was performed seeking to fulfill the requirements of reliability and internal and external validity. Concerning the reliability and internal validity, we believe that this objective was reached by obtaining adequate fit values, coherent values for the model's coefficients and adequate values for the reliability indexes as recommended by the references. Also for external validity, the obtained results allowed comparisons to be made between companies of the same size and between different sizes, producing results that are in line with what was expected.

The analysis of the relation between the IL and IT investments allowed verifying an aspect considered important: the expense in IT increases with the IL. This means that the companies that choose to use IT at its maximum potential must be aware that this represents additional costs. This is clearly another good reason for investments in IT to be made in an appropriate way, so that the actual benefit achieved is in reality proportional to these investments.

With regard to the "IT conversion factor" was observed that the smaller companies benefit from a possible "leverage" effect due to their reduced need to use sophisticated technology. This was evidenced by the observation that they "convert better" their IT investments into IL (in absolute values), indicating that they can informatize relatively more, using simpler technology. This argument is coherent with the philosophy of IT use that permeates the construction of the IL: the companies shall invest in effective use rather than in sophistication.

It is also worth noting that the correlation between IT investments and the informatization level revealed to be very slender, as expected based on the analysis of the theoretical referential. This is an indication that companies should invest in the improvement of their conversion factor. Broadly speaking, this means that it is necessary to invest in the culture of IT professionals, users and executives concerning the importance of using the technological resources correctly. This recommendation is in line with what was expected by the authors on the development of the measurement of the informatization level: to contribute toward the identification and analysis of factors that can support companies, so that they may reach their correct informatization level.

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