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Measuring the Financial Benefits of IT Investments on Coordination

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We know from the information processing perspective within the theory of organizations that IT can reduce coordination costs by increasing an organization's information processing capacity. Purpose of this paper is to empirically examine the relationship between greater investments in information technology and lower coordination costs on firm-level data. Two high-level measures of coordination costs are defined based on the information processing perspective within the theory of organizations. Our hypothesis that greater IT investments should be correlated with lower coordination costs is tested with both measures on longitudinal data from a cross-sectional sample of 18 large Italian companies over an 8-year period between 1988 and 1995. Results on this sample seem to support our hypothesis by showing a significant and negative correlation both aggregately and on sub-samples of data clustered by industry.

IT benefits are often objectively difficult to quantify, since they affect aspects of performance, such as responsiveness and flexibility, which cannot be assessed in terms of direct measures such as cost reductions or productivity improvements. These objective difficulties in assessing the benefits of IT investments have been addressed in a number of different ways. For example, to support individual investment decisions, cost-benefit analysis has attempted to de-emphasize quantitative criteria in favor of qualitative ones (cf. Parker et al., 1988; Willcocks, 1992). A qualitative approach to investment justification has been proposed not only on the basis of the intangible nature of IT benefits, but also on the interdependencies among different investments. The returns of an investment can be either made contingent on, or possibly amplified by, the successful realization of other investments and are thus difficult to quantify in isolation. On the other hand, these interdependencies also suggest that benefits may be apparent at an aggregate level. Some authors have noted that, although individually intangible, benefits from different investments are captured by firm-level economic indicators which are influenced by overall IT expenditures (cf., Roach, 1989; Roach, 1991; Strassmann, 1990). This research takes this last perspective and researches aggregate measures of IT returns.

Much of the research taking this perspective has relied on analyses that tie IT investments to firm economic performance through indicators such as financial ratios (Loveman, 1988; Roach 1989; Roach, 1991; Weill, 1992; Bryjolffson and Hitt, 1993; Venkatraman and Zaheer, 1990). As recently surveyed by different authors (Smith and McKeen, 1993; Brynjolfsson, 1993; Blyth, 1995), empirical research using these indicators has failed to provide conclusive evidence suggesting increased business performance related to higher IT investments. Some authors have found a weak or negative correlation between investments and performance (Loveman, 1988; Strasmann, 1990; Cron and Sobol, 1983; Weill, 1992;

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Venkatraman and Zaheer, 1990). Other studies suggest, on the contrary, a positive correlation (cf., Brynjolfsson and Hitt, 1993; Harris and Katz, 1991; Siegel and Griliches, 1991; Alpar and Kim, 1990; Krueger, 1993). A number of explanations have been advanced to try and reconcile or explain the inconsistency between these different findings. For example, in some cases, IT can be considered a necessary condition for a company to remain competitive, rather than an opportunity to increase its performance. Alternatively, IT could be beneficial to individual firms, but at the expenses of other competitors, thus resulting in tentative findings at an industry level.

This paper focuses on the possibility that conflicting results have occurred partly due to inappropriate measures of both investment and performance variables (cf,. Brynjolfsson, 1993). Smith and McKeen (Smith and McKeen, 1993) note that IT contributes to performance either by increasing the productivity of labor or by generating revenue through the creation of new products and services. Most of previous research works have relied on traditional indicators of business performance that provide assessments of productivity. For example, ROI provides indications of a company's productivity, since it increases as the income grows with respect to total assets, but it does not necessarily express variations in the size of the business. On the other hand, IT investments have not always been defined precisely to include only technology outlays whose impact can be measured by the selected performance indicators. Historically, there have been definitional problems in information systems research (cf., Keen, 1980; Bakopoulos, 1985) and how information technology is defined varies from broad conceptualizations which include technologies such as typewriters, facsimiles, and telephones, to very narrow ones which consider specific application programs for a given firm. Keen points to a general lack of theoretical foundation in the information systems research field (Keen, 1980). In this research, we try to ground both IT investment and performance indicators on the same theoretical view of how IT affects organizations and their performance.

An interpretation of the information processing perspective within the theory of organizations is discussed in order to identify and define the organizational role of IT. The information processing perspective explains how information technology can increase an organization's information processing capacity and, consequently, reduce the organizational costs to process information, referred to as *coordination costs*. We define *working capital* and *structure costs* as proxies of coordination costs and use them as indicators of aggregate IT performance. While the first proxy measures coordination costs from the cost-income statement, the second measures the capital invested to finance coordination costs from the balance sheet. Different information technologies are classified based on their organizational roles. The category of IT that plays a coordination role and has the potential to reduce coordination costs is selected for investigation. The correlation between higher investments in this category of IT and lower coordination costs is tested on longitudinal data from a sample of 18 companies. The correlations that are found are not meant to propose our measures of coordination cost as the only organizational variables that highlight the opportunity of investing in IT. Rather, the intent is to suggest a higher attention to the conceptualization of the variables measuring IT investments and corresponding benefits.

The presentation is organized as follows. First, our theoretical approach to the investigation of IT benefits is discussed. This is followed by the definition of the performance indicators and their testing. The paper concludes by discussing the limitations of the proposed approach and suggesting directions for future research.

Theoretical Aspects of IT's Impact on Business Performance

The information processing perspective within the theory of organizations has explained how the amount of information needed by organizations to make decisions increases as environmental uncertainty grows (Galbraith, 1973; Galbraith, 1977; Simon, 1976; Tushman and Nadler, 1978; Randolph, 1978; Daft and Macintosh, 1981; Robey, 1981; Mackenzie, 1984; Daft and Lengel, 1986; Huber and McDaniel, 1986; Lee and Leifer, 1992). In this stream, organizations are assumed to be complex information processing entities with an overall information processing capacity (IPC).

Simon (1976) suggests that, in general, organizations are created to accomplish tasks too complex for any independent subset of their components. For instance, individuals cooperate within organizations to achieve goals beyond the cognitive capabilities of any single agent. Simon (1976) refers to the cognitive limits of decision makers as their "bounded rationality." That is, it is impossible for a single, isolated individual to achieve any high degree of rationality. March and Simon explain that specialization and coordination of different agents within groups are the means to transcend these boundaries of rationality (Simon, 1976; March and Simon, 1958; March, 1994). When we see agents as information processors, their rationality determines their individual information processing capacities and organizations can be regarded as the means for overcoming these individual limits in processing information.

However, Arrow (1974) notes that information must be coordinated to its effective use within an organization. In organized work, the criteria for specialization include purpose, process, or place, but rarely information itself (Bolton and Dewatripont, 1994). For example, where functional specialization is the criterion, organization units are distinguished by the specific bottom-line service they offer, and share various types of information, such as customer profiles,

service track records, and general market trends. If organizations are simply built around their specialization criterion, information is scattered among multiple information holders without corresponding channels of communication. Providing an overall information processing capacity means coordinating the gathering and exchange of this information (Arrow, 1974).

Under the information processing perspective, organizations are considered information processors and coordination consists in enacting information exchanges among different individuals within the same organization. Coordination is a recurrent theme in the organizational literature and has also been more broadly defined as "managing dependencies." This definition is not limited to information interdependencies and extends the focus to coordination mechanisms different from organizations, such as market or groups. Given our focus on the justification of IT investments by individual companies, the information processing perspective can still provide an appropriate lens to focus on organizations and on the impact of IT on their information processing capacity.

Coordinating information exchanges has traditionally been associated with a cost. This cost represents the overhead that organizations incur to achieve the cooperation among their agents, by training, synchronizing and controlling them (Arrow, 1974). The intensity of communication, as well as the organizational form where communication takes place can influence the amount of these overhead costs (Coase, 1960; Arrow, 1974; Williamson, 1975; Ciborra, 1993). The impact of the organizational form has been primarily debated by making a fundamental distinction between two means of coordinating, *markets* and *hierarchies*. The cost of the information *exchanges* associated with these different alternatives are referred to as *transaction* and *coordination* cost, respectively (Williamson, 1975).

By taking the information processing perspective, we emphasize the coordination role of IT and its impact on coordination costs. In Galbraith's analysis, organizations cope with more complex coordination either by reducing their needs or by increasing their capacity for processing information (Galbraith, 1973; Galbraith, 1977). IT addresses the latter alternative. Galbraith refers to a "modern information technology" (Galbraith, 1973) as an important support to organizational information systems. A more adequate IT support for the information requirements of an organization is tied to the ability to improve information processing capacity and, in turn, to reduce the cost of exchanging information.

Convenient IT investments for an organization would result into lower costs of coordinating information to achieve the required levels of information processing capacity. Unfortunately, the concepts of information processing capacity and costs have never been adequately formalized in terms of operationalizable variables. The result is a lack of theoretical or empirical studies that demonstrate their applicability. Research aimed at revisiting the information processing perspective with a more practical orientation has also been recently called for (Bakos and Kemerer, 1992; Malone and Crowston, 1994). Towards this, we attempt an operating definition of the costs of coordinating information within organizations and subsequently test their correlation with higher investments in IT.

Defining Performance and IT Investment Indicators

In the next two sections, we define two indicators for coordination cost, called *structure cost* and *working capital*. They represent an evaluation of the coordination cost based on financial statements of companies. These indicators are tied to IT investment measures that emphasize the coordination role of IT.

Structure Cost and Working Capital

The ease of applicability of traditional financial ratios is among the reasons for their prevalence in the IT performance literature. Most financial ratios can be calculated on the basis of information from official financial documents, such as budget plans or the balance sheet, without requiring *ad hoc* data collections. As noted before, the use of generic ratios, originally defined for broader financial analyses, such as ROI, ROE or ROS, has often lead to a loose relation between performance ratios and IT strategy and investments (cf.,Strassmann, 1990; Brynjolfsson, 1993). On the other hand, specific data for firm-level analyses are particularly cumbersome to gather and, as a result, complex indicators are likely to become impractical.

The indicators proposed here as measures for coordination cost are based on information directly available from the balance sheet and the cost-income statement. In general, the different cost items are reported in the cost-income statement, classified according to macro categories specific to individual companies. A measure of the coordination cost could be obtained as a summation of the costs incurred to finance coordination activities. For example, expenses for administrative staff or external contractors can be considered an overhead cost due to the need for coordinating production activities by supporting the allocation of financial resources to different operating units. However, the categories of cost related to coordination vary widely among firms and are difficult to classify. Consequently, a direct measure of coordination cost obtained as a summation of expenses from the cost-income statement is hard to obtain.

To overcome the aforementioned difficulties, the coordination cost can be viewed as a difference between total and operating production costs. By definition, coordination is comprised of activities non directly related to production, but necessary to achieve the cooperation among multiple agents and the execution of complex organizational tasks. As opposed to coordination costs, the items included in the cost of

Operating costs	- Costs of Raw Materials
	- Costs of left-over Stock
	- Costs of Production Labor
	- Costs of External Services Related to Production
	- Costs of Amortization Related to Production

Table 1: Classification of operating costs.

operations are relatively standard among firms. While coordination costs depend on a company's processes which often represent a strategic determinant of differentiation, production involves a set of basic costs typically common across different processes. Table 1 reports a possible classification of operating costs. In practice, some of the cost items in Table 1 may be considered difficult to separate from the cost of coordination. For example, line work can involve a coordination effort to synchronize different production tasks and, consequently, the cost of production labor may include a coordination cost. However, the difference between total and operating costs can still be used since such hidden coordination cost constitutes in practice a small fraction of the total production cost.

A first measure of coordination costs can be obtained by subtracting operating costs from total business costs in the cost-income statement. This measure, which we refer to as *structure cost*, is defined as follows:

Structure Cost= Total Business Costs - Operating Costs

Current expenses as reported in the cost-income statement involve a corresponding financial cost, which is determined by the amount and the composition of the capital needed to finance those economic operations. A measure of the financial cost caused by expenses for coordination would provide a proxy of coordination costs. The balance sheet distinguishes long from short term capital investments, since the time-frame of both assets and liabilities is a major determinant of their financial cost. A long-term impact is most likely due to a combination of IT choices and additional organizational variables such as corporate strategy and changes in organizational structure (cf. Andrews, 1980; Chandler, 1962). Since we focus on IT as the primary independent variable responsible for changes in coordination costs, we believe it is difficult to account for long-term effects of IT investments. Consequently, we consider the impact of IT on the short-term or current items of the balance sheet. Specifically, by supporting coordination, IT may reduce the share of short-term invested capital necessary to maintain current expenses. This share of invested capital is the difference between short-term assets and liabilities, referred to in accounting as working capital.

A second measure of coordination costs can be obtained by calculating the *working capital* as the difference between current assets and liabilities in the balance sheet:

Working Capital= Current Assets - Current Liabilities

Notice that the working capital can be also interpreted in the light of Galbraith's analysis of uncertainty (Galbraith, 1973; Galbraith, 1977). Organizations respond to uncertainty by augmenting their information processing capacity, or by reducing their information needs. One way of reducing information needs is to equip production processes with slack resources that can absorb delays in processing information. According to Galbraith (Galbraith, 1977), IT can avert the need to resort to slack resources necessary for decreasing the amount of information to be processed. From a financial perspective, the smaller this "slack," the lower the difference between short-term assets and liabilities reflected in *working capital*.

Definition of IT Costs

Companies use broad definitions of IT that include technologies whose impact is often different from coordination. To isolate coordination technologies, IT can be classified into the following categories:

1) Information technology embedded in the production process of an organization's products or services. Examples include robots, numerical control machines, process control machines, diagnostics or quality checking machines, automatic teller machines and cash recorders.
2) Information technology that is part of an organization's products or services. This type of IT includes calculators, on-board instrumentation of cars, and automatic teller machines for banking services.
3) Information technology employed in the management of organizational production processes. Examples are accounting applications, personnel management programs, electronic mail, teleconferencing, spreadsheets, decision support systems in general, and executive information systems.

Similar classifications have been proposed in the literature (cf., Strassmann, 1990; Weill, 1992), in a common effort to define a sufficiently homogeneous set of information technologies. However, our categories present some differences from previous classifications. For example, Weill (1992) classifies IT as transactional (e.g., order entry), informational (e.g. e-mail) and strategic (e.g., inventory systems). In our approach, all three of Weill's classes of IT fall under the third category, since they all target the support of management functions. With respect to other definitions, our categories are more directly tied to the coordination role of IT as theorized under the information processing perspective.

For our purposes, the term *information technology* will refer only to the third category, that of IT used in *management* functions. That is, those necessary to direct or support the cooperation among multiple agents or groups of agents within organizations (Scott, 1992). Management represents a straightforward term for companies to indicate coordination. Note that our categories of IT are not always mutually exclusive. For example, insurance IT applications may be used both to coordinate the production of their services and to actually produce and deliver them to customers. Information technologies applied in management as well as in other functions will be considered for analysis, as they nevertheless play a coordination role.

Traditional information systems, such as payroll or administrative IT applications, are primarily targeted to the support of management, including both line and staff responsibilities. In most companies, information technologies are still applied to support this classical set of management functions, notwithstanding the emphasis on the strategic role of IT as a component of products and services. Correspondingly, the costs of IS departments are mostly devoted to management ITs. This suggests to define IT costs as a function of the costs of a company's IS department. However, the total cost of the IS department, especially in manufacturing companies, may include costs of information technologies exploited in line production, which according to the categorization above, are excluded from our definition of IT. A measure of IT costs can still be obtained from the total costs of the IS department by subtracting the costs of line technologies:

IT Costs= Total IT Costs - Production Line IT Costs

The first two categories of IT in our classification would present different difficulties in benefit assessment that are outside of the scope of this paper. The advantages of IT embedded in production processes (first category) can be assessed via more traditional financial techniques, such as the ROI method (cf. Parker et al., 1988). In the balance sheet, the costs of this category of IT are directly included in the cost of goods sold since, by definition, they are directly related to production. The second category of IT, part of a company's products or services, is really strategic and a source of competitive advantage. Assessing this second category's economic benefits requires more qualitative techniques commonly used for the valuation of new products or services (Porter and Millar, 1985; Blattberg et al., 1994).

Testing Methodology and Results

The relationship linking coordination costs to IT investments can be thought of as curvilinear starting from a non-null value of coordination costs corresponding to null investments. Increasing IT investments would reduce coordination costs up to a minimum value, in general different from zero. Both very low and very high levels of IT investments would reduce coordination costs at a low rate, while intermediate levels of investments would have a greater impact. Intuitively, too low investments in IT do not allow a critical mass of users necessary to substantially change a company's coordination practices and costs; likewise, additional investments have a limited effect above a threshold where information processing requirements are sufficiently satisfied. As a consequence, the relationship linking coordination costs to IT investments would have a point of inflection between high and low levels of investment. Note that this type of curvilinear relationship has been proposed for various coordination mechanisms in the organizational literature, particularly under the information processing perspective (cf., Scott, 1992). A classical example is that of hierarchies, which are costly coordination mechanisms under conditions of low uncertainty, but are efficient information processors in complex environments up to a certain level of uncertainty where their performance starts deteriorating (Blau and Scott, 1962).

In a range around a point of inflection, a linear model involves a smaller error to interpolate a generic relationship. By assuming that companies are able to set their IT costs within the most convenient range, i.e., around the point of inflection, a linear model will be used for empirical testing. The linear models tying IT costs to structure costs and working capital, respectively, are shown below. Table 2 explains the mathematical symbols in these models.

$$SC_i = m_{SC} ITC_i + SC_0 \qquad (1)$$

$$WC_i = m_{WC} ITC_i + WC_0 \qquad (2)$$

According to these models, IT reduces coordination costs if the interpolator straight line of the test data has a negative slope, i.e. $m_{sc}<0$ and $m_{wc}<0$. Although indicated in the formulas, the values of structure costs and working capital corresponding to null IT investments (SC_0 and WC_0, respectively) will not be calculated from the data, as they would require the study of a more complex mathematical relationship between IT and coordination costs. In the next section, we briefly discuss the data on which these linear regressions have been tested.

Symbol	Meaning
SC_i	Structure costs at year i
WC_i	Working capital at year i
ITC_i	Information technology costs at year i
m_{sc}	Reduction coefficient of structure costs
m_{wc}	Reduction coefficient of working capital
SC_0	Structure costs without IT
WC_0	Working capital without IT

Table 2: Mathematical variables and symbols.

Data Sample and Source

A longitudinal sample from 18 companies is used for testing. Data span an eight-year period (from 1988 to 1995), with an additional year (1996) of budget data. They have been collected among the activities of a permanent research observatory on IT investments and business strategies. The criteria for choosing the companies in the panel include financial performance, market share and size as measured by revenue. The selected companies represent leaders in their industry according to these criteria and have survived throughout the study period. Companies belong to four different industries: chemical/pharmaceutical, mechanical, textile, and utilities (classified as local and national in the following).

While the number of firms for industry-level analyses is not large, the companies' interest and active participation guarantee higher data reliability. This allows us to make some initial inferences about the relationship between IT investments and coordination at an industry level and cross-sectionally. Data are collected according to a template agreed upon by all participating organizations, which includes general financial information, disaggregate IT investments, IT application portfolio and industry performance benchmarks. Data are periodically discussed in meetings of the entire panel, to support the overall analyses and interpretation of results.

Results

The absolute value of coordination costs varies significantly with the industry where an organization operates. In general, highly process-based industries, such as chemicals, need less resources to coordinate their production activities than services, where operations are less standardized and require continuous rethinking and adjustment. Similarly, organizations in different industries generally set different levels of IT costs as a percentage of their revenue.

To account for differing absolute values of coordination and IT costs, data are analyzed on a per-industry basis. However, companies within the same industry can still have values of coordination and IT costs different by orders of magnitude. Firm size is a primary factor contributing to this variance. As an example of the influence of size on costs, a company that doubles its size by integrating horizontally through the acquisition of a second identical company will have close to double the coordination costs. In general, the ratios of coordination and IT costs to an indicator of firm size become comparable across different companies. Accordingly, we assume the relation between SC, WC, IT expense and size to be a linear function and test our main hypothesis by seeking a correlation among ratios as opposed to absolute values.

The *value added* is used here as an indicator of firm size and is defined as revenue less purchases (Strassmann, 1990). Firm size can be analyzed along two dimensions, referred to as horizontal and vertical, respectively. The former represents the firm production capacity, while the latter represents the portion of the value chain covered by the firm. In turn, vertical size can be due to either upstream or downstream integration of production activities. Changes in both the horizontal and vertical size of a company are reflected by a corresponding variation in the value added. On one hand, increases of production capacity as well as downstream integration lead to a corresponding growth of revenue; on the other hand, upstream integration leads to lower levels of purchases. Other more commonly used financial indicators provide a less complete measure of size. For example, with revenue, probably the most commonly used indicator of firm size (Scott, 1992), it is more difficult to measure the effects of upstream integration of production activities, as revenue emphasizes the downstream growth of a firm's business.

Table 3 summarizes the results of testing the correlation between higher IT expense and lower coordination in different industries. Results are reported for both SC and WC as indicators of coordination costs. The slopes m_{sc} and m_{wc} (see models (1) and (2) at the beginning of Sect. 4), the coefficient of determination R^2, and the level of significance measured by the Fisher F are reported in table columns, while the rows describe the results within each industry.

Correlation has also been tested across different industries with the entire data set collected from the observatory. For this purpose, data have been normalized by dividing each data point in a company's historical series by the first data

	SC			WC		
	m_{sc}	R^2	Significance (Fisher F)	m_{wc}	R^2	Significance (Fisher F)
Textile	0.85	0.78	p<2.5%	-0.42	0.26	p<10%
Mech.	-0.14	0.47	p<5%	-1.25	0.54	p<5%
Chemical	-0.19	0.36	p<5%	-0.46	0.31	p<10%
Nat-util.	-1.24	0.62	p<1%	-9.54	0.67	p<0.5%
Loc-util.	0.11	0.24	p<10%	-0.16	0.19	p<10%

Table 3: Summary of results for individual industries.

	SC			WC		
	m_{sc}	R^2	Significance (Fisher F)	m_{wc}	R^2	Significance (Fisher F)
Obs.	-1.26	0.60	p<0.5%	-4.47	0.33	p<0.5%

Table 4: Summary of results across industries.

point. These normalized historical series start from the same unitary value. A generic datum in a normalized series represents the percent variation of either structure costs or working capital with respect to a given percent variation of IT expense. We consider these percent variations more comparable across different industries. A more intensive use of IT should cause a percent reduction of SC and WC related to a more appropriate use of coordination tools and therefore similar across different industries. Table 4 summarizes the results of testing across different industries.

Our sample of companies amortizes their IT investments with constant depreciation allowances over three or five years, depending on the specific technology. However, IT investments have returns which are typically non-constant. The literature documents significant time lags between investments and payoffs, which are not always considered by accounting methods and can be a likely cause for the weak relation between IT investments and returns in previous studies (Brynjolfsson, 1993). Benefits are generally low initially and maximum in the central phase of the investment life cycle. Especially for long-term investments, ignoring this distribution of benefits can involve a non-negligible error. By collecting IT investment in addition to expense data, we have been able to test correlation also with depreciation coefficients spanning a 8-year period and maximum in the 3rd and 4th years of investment. Table 5 reports the results of testing with a non-linear amortization of IT investments.

Discussion

Higher IT costs are found to correspond to lower coordination costs as measured by *working capital* in all the industries (see Table 3). This trend is also verified with both *working capital* and *structure costs* at an observatory level (see Tables 4 and 5). However, *structure costs* show a positive correlation with IT costs in some of the industries, namely textile and local utilities. Overall, these results seem to confirm our hypothesis that higher IT investments correspond to lower coordination costs.

In the utility industry, competition is generally higher for companies operating at a national level than for local utilities. Companies in our sample operating locally typically leverage niches that they are able to defend from competitors through a better knowledge of their local market and favorable regional regulation. These conditions may contribute to make local utilities more bureaucratic and less concerned with improving the efficiency of their organization structure. Accordingly, IT investments may focus on providing support for the activities critical for the company's niche rather than enhancing the efficient management of administrative and coordination processes. These types of investments would have a limited impact on coordination costs and would require a more in-depth investigation of a company's business strategy in order to understand their benefits.

The individual behavior of a few firms could be responsible for the overall trend of coordination costs in the textile industry. One of the companies shows a marked decrease of

	SC			WC		
	m_{sc}	R^2	Significance (Fisher F)	m_{wc}	R^2	Significance (Fisher F)
Textile	0.13	0.16	p<10%	-0.78	0.51	p<10%
Mech.	-0.44	0.26	p<10%	-1.81	0.47	p<5%
Chemical	-0.29	0.33	p<10%	-1.33	0.38	p<10%
Nat-util.	-1.00	0.43	p<5%	-8.06	0.54	p<0.5%
Loc-util.	0.91	0.74	p<1%	-0.14	0.51	p<2.5%
Obs.	-0.5	0.46	p<1%	-3.08	0.25	p<0.5%

Table 5: Summary of results with non-linear amortization of IT investments

structure costs and a constant IT expense over the period of investigation. We know that this decrease of SC was caused by an effort to contain costs through other means in addition to IT, such as the outsourcing of particular administrative support functions. This company, a traditional leader in the textile industry, was also endowed with an IT infrastructure more advanced than the industry average and was still benefiting from the heavy investments in IT prior to 1988.

Among the industries verifying our hypothesis, the relationship between coordination and IT costs is stronger in more information intensive sectors. Interestingly, national utilities have the highest slope of the linear function relating coordination costs to IT investments and is probably the most information intensive sector that has been considered here (see Tables 4 and 5). In these sectors, information is typically a primary resource for both production and managerial processes. Accordingly, information technology can have a wider applicability and a potentially stronger impact on coordination costs. Smith and McKeen have suggested as a proposition for investigation that the relationship between IT usage growth and business revenue growth should be stronger in more computerized industries (Smith and McKeen, 1993). Our findings seem to propose more generally that IT benefits in terms of cost reduction grow with computerization more than proportionally.

An explanation of these trends in information-intensive industries can be found in previous information processing theory. The coordination effort in an organization has been recognized to grow more than proportionally with the complexity of production activities (Galbraith, 1973; Galbraith, 1977). For example, the hierarchy of authority has been proved to collapse if complexity increases above a certain threshold that depends on the number of levels of authority and their span of control (Scott, 1992). This degradation of the hierarchy's performance has been found to be non-linear and happen almost abruptly as complexity increases. Since the amount of information to be processed by an organization is a source of complexity, these considerations suggest that the effort to coordinate grows more than proportionally in information-intensive businesses. Correspondingly, in these businesses, the potential impact of IT as a technology supporting coordination can increase more than proportionally.

The relationship between coordination and IT costs is stronger when a non-linear amortization is applied to IT investments (see Table 5). Benefits are not constant over the life of an IT investment, being instead higher after a few years from the initial investment. This non-linearity could be compensated by continuous investments over an extended period of time whose combined amortization would have lower variability. However, IT is an evolving technology and can require waves of investments to introduce new infrastructural technologies (cf., Galal, 1996). For example, in the early 1990s, companies invested in their network infrastructure and are now undergoing a second wave of investment to shift to client/server architectures building on this infrastructure. This is consistent with Brynjolfsson who points to a lag between investments and returns as a likely cause for mismeasurement of the organizational impact of IT (Brynjolfsson, 1993).

Another noteworthy finding is that within the same industry the correlation is generally stronger with the *working capital* than with *structure costs*. The focus here is on the category of information technology employed in the coordination of production processes (see Sect. 3.2). The costs related to IT as a coordination technology are therefore part of coordination costs and, as such, increase it and partly hide the decrease yielded by actual IT use. On the other hand, working capital usually does not reflect IT investments because they are generally considered long-term investments when capitalized.

As a final commentary, previous studies have often found a bimodal distribution of their sample data. In these cases, companies exhibited high IT spending with either very high or very low returns (cf. Smith and McKeen, 1993; Wilson, 1995). A common interpretation is that equipping firms with advanced technologies is not sufficient to make them financial performance leaders. Large IT investments may even affect a firm negatively by using up resources that could be invested in other more critical areas of the business. Bimodal results suggest that investing in IT as laggards in performance within an industry can be counterproductive. However, we have noted how companies in our sample are typically well managed and leaders in their industry. Accordingly, they show a consistently non-bimodal behavior, that is, a simple correlation between IT investments and cost reduction benefits related to coordination.

Conclusions

Although it has been theoretically proposed that information technology supports coordination, quantitative evidence has traditionally been limited. The findings presented in this paper are preliminary, but they suggest an empirical relationship between higher IT investments and lower coordination costs. This correlation varies across industries, being stronger in information-intensive ones, where information is a more critical resource.

The tentative results from numerous attempts to demonstrate the impact of IT on organizational performance using classical financial ratios motivated our effort to provide definitions of IT benefits with a theoretical foundation. We have presented two proxies for coordination costs that have allowed us to study the coordination cost benefits from IT investments at a high level. *Working capital* and *structure costs* are easily applicable, since they are calculated from financial statement data. However, they are biased by accounting considerations and do not only reflect the factors that determine coordination costs.

The relationship between IT investments and our cost-based measures of benefits could be refined by addressing how the actual usage of IT delivers returns. More detailed definitions of information processing capacity could be proposed to help substantiate how the information processing perspective can explain the coordination impact of IT. A model of how IT is applied in organizational processes and how it affects their information processing capacity could support more accurate measures of coordination costs, based, for example, on more detailed cash-flow information from operations. These measures could in turn be used to further validate our results and would constitute a basis for a broader methodology to the justification of IT investments based on the information processing perspective.

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