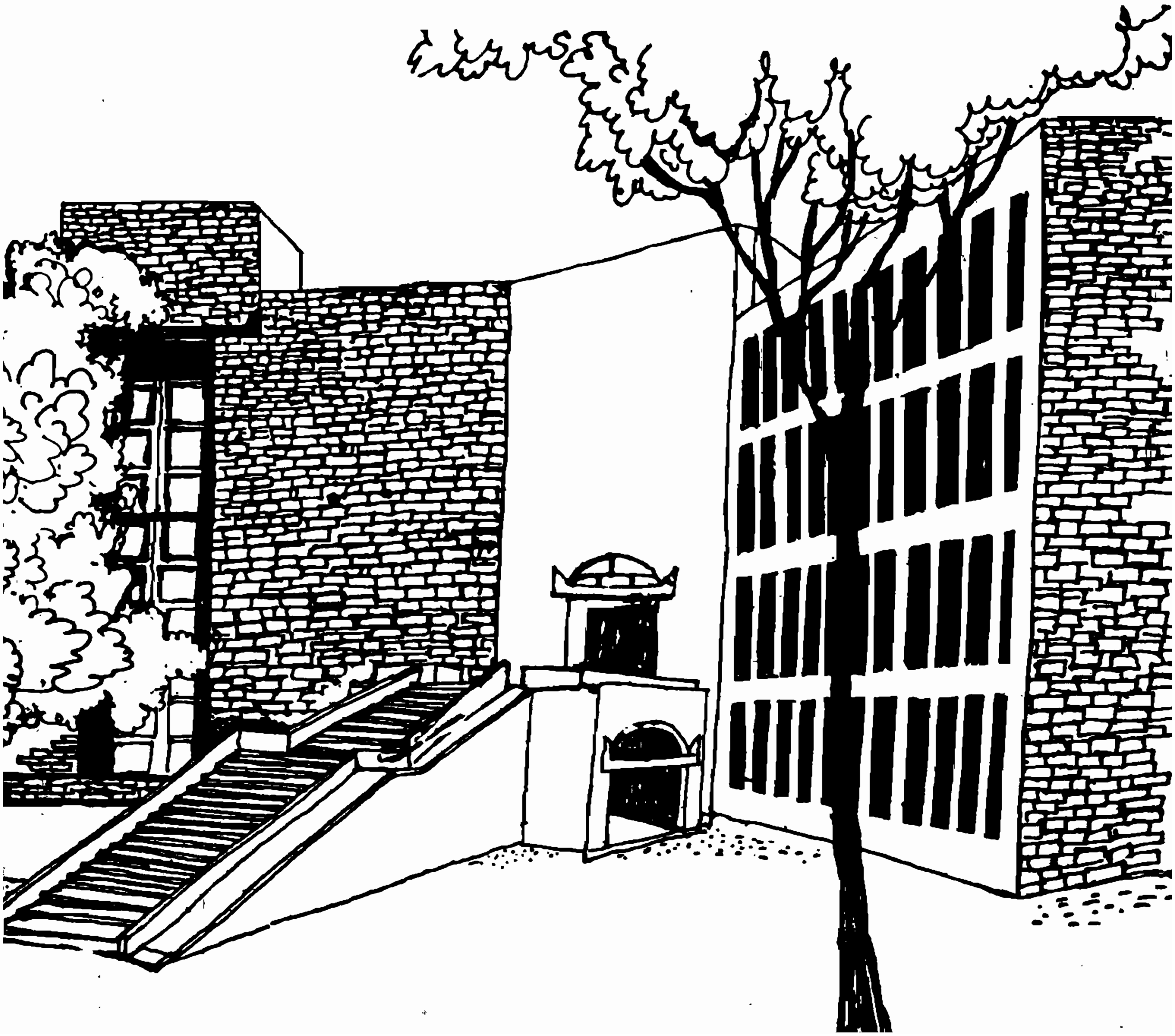
विद्याविनियोगाद्विकासः

IIM

AHMEDABAD

Working Paper



Empirical Assessment of Coherence in Information Technology Firms

D Karthik
Rakesh Basant

W.P. No. 2004-12-01
December 2004

The main objective of the working paper series of the IIMA is to help faculty members, Research Staff and Doctoral Students to speedily share their research findings with professional colleagues, and to test out their research findings at the pre-publication stage

INDIAN INSTITUTE OF MANAGEMENT
AHMEDABAD-380 015

Empirical Assessment of Coherence in

Information Technology firms

D Karthik*	Rakesh Basant
Doctoral student, Economics Area	Professor, Economics Area
Indian Institute of Management, Ahmedabad	Indian Institute of Management, Ahmedabad
Dorm 19, Room No. 33	Wing 07
Vastrapur, Ahmedabad – 380015	Vastrapur, Ahmedabad – 380015
dkarthik@iimahd.ernet.in	rakesh@iimahd.ernet.in
Tel: 079-26326983	Tel: 079-26324865

*Corresponding Author

This version: November 30, 2004

Abstract

Coherence is the ability to discover new – potentially profitable – combinations of various types of knowledge assets where complementarity is the basis for relevant combinations. Assets are considered complementary if doing (more of) any one of them increases the returns to doing (more of) others. Despite its strategic importance, few studies have addressed the issue of coherence in the Information Technology (IT) industry. This paper develops a novel methodology assess the extent of complementarity and coherence in the IT firms grounded in 'sensemaking', evolutionary economics, and strategic management. This paper uses managerial perspective for defining businesses. Managers and IT experts identify a typical IT firm based on the dimensions of applications (verticals) and specializations (service lines). Another feature of this paper is the use of survivor principle for assessing complementarity.

The results on complementarity suggest that in case of applications, the boundaries between *Transport & Ports* and *Airlines & Railways* are getting blurred and these could become a generic combination. Similarly, in case of specializations *Software maintenance migration* and *RDBMS, Datawarehousing & Datamining* could become a generic combination.

The results also suggest that there is substantial scope for improvement in coherence in both applications and specializations. Analysis of coherence also indicates greater fungibility of knowledge in applications than knowledge in specializations. Another finding is that the IT firms retain coherence with large number of applications but not with large number of specializations. Finally, as the number of applications and specializations reach a critical limit, the average coherence shows a definite decline.

Contents

I. Introduction

Coherence has been an important research issue in corporate strategy. Its significance can be gauged from the importance attached to the underlying theoretical concepts - related diversification, dominant logic (Prahlad and Bettis, 1986), and core competence (Prahlad and Hamel, 1990). These concepts also underline the fact that similarity between the businesses can be a basis for achieving sustainable competitive advantage (Iversen, 2000). Besides, measurement of coherence can aid the CEOs in striving for more coherence, which has been associated with efficient performance. This view is based partly on studies that have found no evidence of unrelated diversification bringing in long-term benefits to the firms (Rumelt, 1974, 1982; Ravenscraft and Scherer, 1991; Porter, 1987; Kaplan and Weisbach, 1992) and partly on evidence of negative stock market returns to unrelated diversification (Bhagat, Shleifer, and Vishny 1990; Berger and Ofek, 1995; Comment and Jarrell 1995). It needs to be noted, however, that the cumulative evidence from studies is far from consistent; there was no relationship found or the relationship found (positive, negative, or curvilinear) explained a small part (relative to business-unit and industry level influences) of total variance in performance (Bood, 2001; Stern and Henderson, 2004). The coherence measure can also be used in research areas where other diversification measures have been used to analyze issues relating to restructuring, refocusing, governance, merger, divestiture, top management team turnover, strategic change, portfolio strategy and financial performance, corporate focus and shareholder wealth, and diversification discount (Robins and Wiersema, 2003).

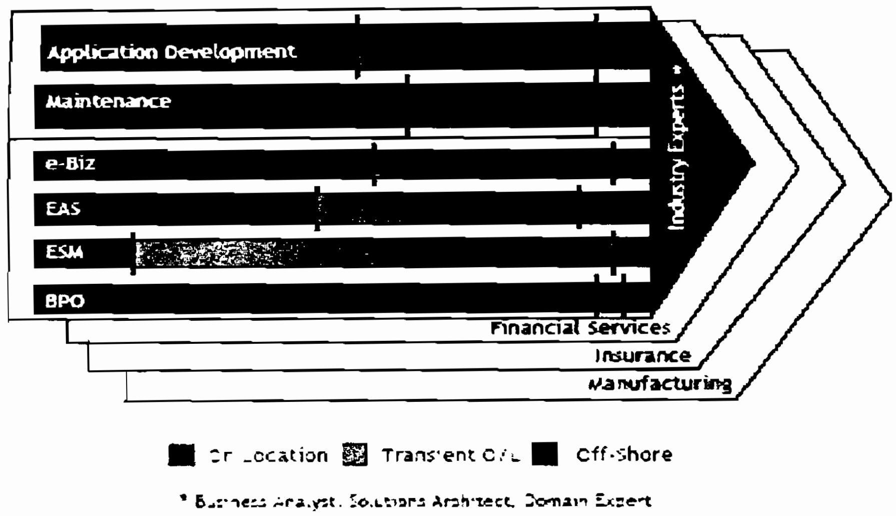
Information technology (IT) in India is considered important not only for growth within the IT sector but also for its potential to boost productivity in other sectors.

Despite its strategic importance and attractiveness, few studies address the issue of corporate strategy in general and coherence in particular in Indian Information technology firms. The reasons for lack of studies are:

- Inadequate coverage in the classification systems like National Industrial Classification (NIC) for example in NIC, 2004, IT companies are classified under the broad heading "Software publishing, consulting and supply" – group No. 722, which is insufficient to capture the heterogeneity in IT industry;
- Diversification is traditionally viewed as a cross-industry phenomenon studied at the corporate level (Stern and Henderson, 2004). Research in the area of within industry diversification is sparse (c.f. Stern and Henderson, 2004); and
- Difficulty in capturing the two dimensional nature of IT industry. Traditionally diversification has been measured using the number of industries spanned by a firm. However, in the case of IT firms we need to explicitly deal with two dimensions - "applications" and "areas of specialization." A typical firm in IT industry may operate in more than one application as also in more than one specialization. What is unique about IT industry is that a typical IT firm combines knowledge in applications and specializations to deliver various IT services. For example, the business model of one of the IT companies in India is shown in Exhibit 1. Application Development, Maintenance etc. are specializations and Financial services, Insurance etc. are applications. The business model entails combination of applications and specializations to deliver IT services through various delivery channels like

onsite, off-shore etc. The existing measures do not consider any dimension other than industries spanned by a firm.

Exhibit 1: Business Model of Patni Computer Systems Ltd.



Source: Chairman's speech, Retrieved on November 20, 2004 from http://www.patni.com/investors/NKPSpeechAGM_June04_Business%20model.pdf

This paper addresses issues pertaining to appropriate scope of an IT enterprise; the number of applications and areas of specialization a typical IT firm should get into. And more importantly, it develops criteria that can be used by firms to choose the applications and areas of specializations that share similarities with its existing applications and areas of specializations so that they can reap the advantages of synergy. In other words, we develop a novel methodology to measure coherence in IT firms and demonstrate its managerial usage in choosing applications and areas of specialization.

The rest of the paper is organized as follows. Section II discusses the concept of coherence and emphasizes its importance for IT firms. Section III makes a case for a managerial approach to the measurement of coherence and diversification. This is followed in section IV with a discussion of the methodology for measuring coherence and relatedness. Section V uses this methodology to illustrate the extent of relatedness in Indian IT industry for the year 2002. In Section VI we discuss the managerial uses of this measure and we conclude the paper by identifying a few limitations of the study and future directions that such research can take.

II. Coherence and its importance for IT firms

II.1. The concept of coherence

Coherence, a term coined by Teece et al (1994) is defined as the ability of firms to generate and explore 'synergies' of various types. Foss and Christensen (2001) point out that the notion is not new and is represented by ideas such as related diversification, core competence and dates back to the work of Edith Penrose (1959), Alfred Chandler (1962) and Igor Ansoff (1965). Traditionally, synergy has been associated only with the static notion of economies of scope - the notion of reduction in cost due to sharing of resources of various types (Iversen, 2000). However, Foss and Christensen (2001) drawing on the Austrian, Post-Marshallian and Evolutionary economics advocate a process approach to coherence which makes it a dynamic construct. In its dynamic sense, coherence is defined as "system wide capacity to generate and exploit complementarities between localized (e.g. divisional) stocks of knowledge and learning processes" (Foss and Christensen, 2001, p. 2). For our purposes, the essential component of coherence in the notion of dynamic coherence is the ability to discover new – potentially profitable – **combinations** of various types of knowledge assets where relevant combination is based on some complementarity[1]. In economic terms assets are considered complementary "if doing (more of) any one of them increases the returns to doing (more of) others" (Milgrom and Roberts, 1995, p. 181).

---

[1] The concept of complementarity goes beyond economies of scope. Complementarity is based on super-additivity i.e. ROI (a,b) > ROI (a) + ROI (b) where ROI is (Revenues – cost)/Investment While economies of scope is based on sub-additivity is Cost (a,b) > Cost (a) + Cost (b).

II.2. Importance for IT firms

Hence, in the context of knowledge intensive Information technology industry when an IT firm combines knowledge in two verticals, say *Retail* and *Banking,* we can say that the firm is attempting to discover and exploit the complementarities between the stocks of knowledge in these two fields.

Thus, more coherence would imply more complementarity between stocks of knowledge in various fields. This can be a source of sustained competitive advantage since complementarity confers an advantage that cannot be developed over a short duration and which will not materialize unless a firm has expertise in at least one of the fields (Foss and Iversen, 1997).

III. A Managerial Approach to Diversification and its Implications for Measuring Coherence

The discussion so far does not suggest any one to one correspondence between industry categories and complementarity. Infact, in a comprehensive review of literature on diversification Bood (2001) points out that one issue lying at the heart of diversification literature is the fuzziness of both industry and firm boundaries. Diversification has been defined as operating in more than one

- 'product mission' (Ansoff, 1957, 1958),
- 'basic area' (Penrose, 1959)
- 'markets' (Gort, 1962)
- 'business activities' (Rumelt, 1974) and
- 'industry' and 'stages' (Galbraith, 1983)

The inherent problem in defining the above concepts is best explained in the following words:

> All businesses have popular conceptions. Some are narrow and tangible, such as the paper clip or canoe business. Others are broad and vague, such as the so-called transportation or financial services businesses, and this can range to the ethereal, such as the business of reducing function. All of these, no matter how tangible, are ultimately concepts that exist only in the minds of actors and observers . . . It therefore becomes possible, with a little effort and imagination, to redefine a business . . . and so change how it is conducted (Mintzberg, 1988, p. 55)

Mintzberg (1988), therefore, argues that industries and businesses are creation of managers and not of researchers or observers. Hence, we need to look at the manager's conception of businesses. Now the question is how to figure out the managerial conceptualization of various segments in a specific sector, say the Indian IT industry.

It has been argued that the definition of business and diversification exists in the mind of the managers and results from managerial sensemaking[2], which in essence reflects a process of managerial and organizational learning. This view is based on the work of several authors who have stressed that diversification is in essence a process of *organisational learning* (e.g. Miles, 1982; Kazanjian and Drazin, 1987; Ginsberg, 1990; Mintzberg, 1990b). According to this view, if the managers of the diversifying company construe new business as fundamentally different from its existing businesses, it is diversification (Bood, 2001). As summarized by Bood (2001) the learning perspective on diversification highlights (at least) three important elements of diversification:

- Diversification involves organizational learning during which knowledge and skills are developed

---

[2] Sensemaking, a term associated with Weick (1979, 1995) in this context means that managers through ongoing process of reflection on past experiences develop their own conception of business their firm is engaged in.

- Diversification involves *experimentation*
- Relatedness between new and existing businesses should be perceived in terms of similarities and dissimilarities of existing and required knowledge and skills rather than in terms of products and SIC-codes.

In order to operationalize this broad understanding in the context of IT industry one needs to look at the way managers and IT experts conceive their businesses. It was observed that a typical firm in the IT industry is identified in terms of its "applications" and "specialization." This is evident from the disclosures in annual reports in the form of segmentation of sales in terms of applications and specializations and from the newspaper reports on mergers, acquisitions and alliances, where applications and specializations are the focus of attention. Applications also known as verticals are the different user industries, which are the consumers of IT services. Applications could be defense, engineering, retail, banking etc. Specializations also known as horizontals or service lines is the categorization of the various services, which fall under the gamut of IT services. Commonly referred to service lines include includes ERP solutions, custom application development, embedded software, call centers etc. A firm may be operating in more than one application as also in more than one area of specialization. A typical IT firm combines knowledge in applications and specializations to deliver various IT services. Hence, we define the business of IT firms as consisting of two dimensions: applications and specializations.

The next issue in measuring coherence is identification of applications and specializations that are related and the extent of relatedness. This is the subject of next section.

IV. Measurement of coherence in IT firms: relatedness

IV.1. Concept of Relatedness

Foss and Christensen (2001) contend that traditional measures of relatedness only look at the industry (whether they share the same higher digit code in NIC classification) or market level (synergies in marketing and distribution) – not at the level of capabilities or other knowledge assets, since they are mostly in terms of economies of scope than complementarities. This was also pointed out by Patel and Pavitt (1997) when they observed that unrelated diversification which is interpreted as inefficient may actually reflect dynamic synergies generated by the diversity of capabilities and other assets.

Relatedness between businesses is dependent the way management conceptualizes each single business as well any particular set of businesses (Mintzberg, 1988; Ginsberg, 1989). In IT context defining complementarities between verticals and specializations could be tricky as it is more subtle and dependent on the way management conceptualizes each single field as well as any particular set of fields. The managers in IT firms can and will continually modify their businesses by redefining, recombining, and reconfiguring them. As mentioned above this is a result of experimentation. The evidence for experimentation as a precursor to diversification is also provided by Miles (1982). By way of illustration, in his research on the six largest U.S. tobacco companies, he observed that the diversification attempts of these companies were preceded by long periods of experimentation and learning (up to fifteen to twenty years):

> Each firm approached the initial occasion of diversification experimentally. They all tended to begin with small resource commitments and with businesses that were closely related to their traditional operations. By trial and error, they gradually built a base of knowledge about diversification and a repertoire of skills for choosing and managing their new domains before committing themselves to a full-blown diversification strategy. (Miles, 1982: 155)

Hence, the criterion we use to assess complementarity should reflect this attribute of experimentation in the behavior of IT firms. Another requirement is that the relatedness criterion should take the manager's perspective of relatedness than that of researchers or observers, since we have adopted the manager's conception of business. Works of Stimpert and Duhaime (1997) and Nayyar (1992) also reflect the need for the above requirement. Their work indicates that the relatedness and the business definition is a result of ongoing sense-making of the management of the company and it is only the management of the diversifying company that can fully indicate what is similar or dissimilar, which itself is the outcome of experimentation. Research by Stimpert and Duhaime (1997) demonstrates that the managers of diversified firms develop their own understanding of relatedness among their firms' businesses and that may include (but also go beyond) similarities in product-market characteristics (captured through same SIC digit codes).

IV.2. Contextualizing the Concept of Relatedness to IT industry

Considering the above, we have chosen the survivor based measure of relatedness. Teece, Rumelt, Dosi and Winter (1994) originally suggested this measure as a measure of coherence. It is based on the observation that the firms do not combine different businesses at random. We are using this to measure complementarity between various knowledge fields. We believe that IT firms do not combine fields of knowledge at random - there is some coherence in the ways IT firms become and remain multi-application/specialization players. This measure is also appropriate because we do not have any a priori hypotheses about the relatedness of two applications or specializations.

This measure finds degree of complementarity directly by looking at how firms combine different fields of knowledge in the real world (Klein and Lien, 2003).

The utility of the measure can be rationalized in a variety of ways:

(i) The observed tendency to combine certain types of businesses, indirectly encompasses all measurable and immeasurable synergies that pertain to such businesses (Zuckerman, 2000);

(ii) The prevalence of such combinations in various IT firms can be taken as an evidence of relatedness and adds legitimacy to the diversification moves of follower firms;

(iii) Moreover it has the potential advantage that it incorporates the knowledge of best informed actors, i.e. the managers (Lien and Klein, 2004); and

(iv) If the decisions are poor then such decisions will get screened by the highly competitive environment in which the IT industry operates which will enforce reversal of poor decisions. Thus, frequency with which firms are found to operate jointly between fields determines their complementarity. As Lien and Klein (2004) observe much of the empirical literature in organizational economics and strategic management assumes efficiency by the extent to which they are observed in reality[3].

IV.3. Measuring Relatedness/Complementarity in IT industry

We use frequency of combinations for measuring the complementarity between knowledge fields. It is noteworthy that there is no need to specify exactly what causes

[3] One of the examples they quote in support for their statement is that of asset specificity (Williamson, 1975). To test whether asset specificity requires more hierarchical modes of governance, researchers regress decision to vertically integrate on a measure of asset specificity. For more discussion on the debate surrounding the efficacy of selection environment to weed out inefficient combinations, see Lien and Klein (2004) and Hunt (2000).

this complementarity. The feature of this measure that we seek to exploit is that it can also capture the immeasurable synergies, which helps us to observe relatedness beyond any a-priori relatedness. Teece et al (1994) originally proposed this measure, but few researchers have subsequently used this measure (cf. Valvano and Vannoni, 2003). In what follows we discuss this measure of relatedness.

Let us consider a population of K diversified firms and define the following variables:

$C_{ik} = 1$ if firm k is active in industry i and 0 otherwise;

$n_i = \sum_k C_{ik}$ and $n_j = \sum_k C_{jk}$ are the number of firms k active in industries i and j, respectively;

$J_{ij} = \sum_k C_{ik}C_{jk}$ is the number of firms simultaneously active in i and j with $0 < J_{ij} \leq \min(n_i, n_j)$.

A measure of inter-business relatedness is obtained by comparing the observed J_{ij} with the number of links that would emerge from random diversification. The latter can be calculated through the hyper-geometric random variable X_{ij} . After having extracted without replacement from a population of K firms two samples n_i and n_j , the probability to find x firms operating simultaneously in i and in j is the following:

$$\Pr(X_{ij} = x) = \frac{\binom{n_i}{x}\binom{K-n_i}{n_j-x}}{\binom{K}{n_j}}$$

The mean and variance of X_{ij} are respectively:

$$\mu_{ij} = E(X_{ij})) = \frac{n_i n_j}{K}$$

$$\sigma_{ij}^2 = \mu_{ij}\left(1-\frac{n_i}{K}\right)\left(\frac{K-n_i}{K-1}\right)$$

The index of relatedness or complementarity is constructed by comparing the observed value of J_{ij} with μ_{ij}, and scaling the difference with the standard deviation of X_{ij} :

$$SR_{ij} = \frac{J_{ij} - \mu_{ij}}{\sigma_{ij}}$$

V. Relatedness in Indian IT industry

We have used the National Association of Software and Service Companies (NASSCOM) Indian IT software and Services Directory - 2002 for identification of the applications and areas of specialization of firms in Indian IT industry. We consider NASSCOM's definition of verticals and specialization as representative of manager's conception of the same.

The sample is representative of the population of IT firms in India because as on 31st December 2002, 854 IT companies in India were members of NASSCOM. The combined revenue of NASSCOM member companies constitutes almost 95 percent of the revenue of the IT software and services industry in India. The directory is published every year and the applications and areas of specialization are updated as per the technological changes happening in the IT sector. The information on applications and specializations is provided for 675 companies, out of which 94 % have mentioned both application and specialization.

The directory provides details of presence or absence of a firm from a set of applications and areas of specialization. The industry relatedness SR_{ij} has been computed using this information[4].

V.1. Complementarity among applications

The NASSCOM directory of 2002 consists of 31 applications and data for 652 firms. However, the information for strongly related applications has been clustered together. For example, Transport and Ports have been clustered together, though we have information on the individual applications as well. Consequently, the complementarity was found to be very high for the fields within these clusters. We then decided to treat these clusters as single applications for further analysis to assess complementarity between not so obviously related applications. The resultant number of applications was 18.

After elimination of 87 firms with presence in only one application, we had data for 565 firms operating in 18 applications. The total possible number of pairs of applications amounted to 153. Not a single pair was found with no firm operating therein. The number of firms in applications pairs varied from 14 to 311.

[4] Since the data reported in the NASSCOM directory can also be seen as a signaling mechanism, it can e argued that the claims of IT firms participating in different applications / specializations are exaggerated. While this may be true, our analysis will remain valid so long as there is no bias in this "over-reporting." Apart from the problems relating to the biases in reporting by firms the interpretation of relatedness scores needs to be undertaken with some caution. Even when one starts with the premise that managers are rational and are able to identify complementarities in a dynamic sense, one needs to appreciate that relatedness scores for a specific year only capture a slice of the evolving complementarities in an industry. In early phases of the industry and/or technological life cycles or in situations of rapid technological change, managers have limited information to assess relatedness. For mature technologies and industries, one could expect the managers to have understood the synergies across segments in a better manner. The Indian IT industry is fairly young and technologically dynamic, making the relatedness scores only indicative of emerging industry dynamics. As a result, the use of these scores for strategic purposes should be cautious. More on this later.

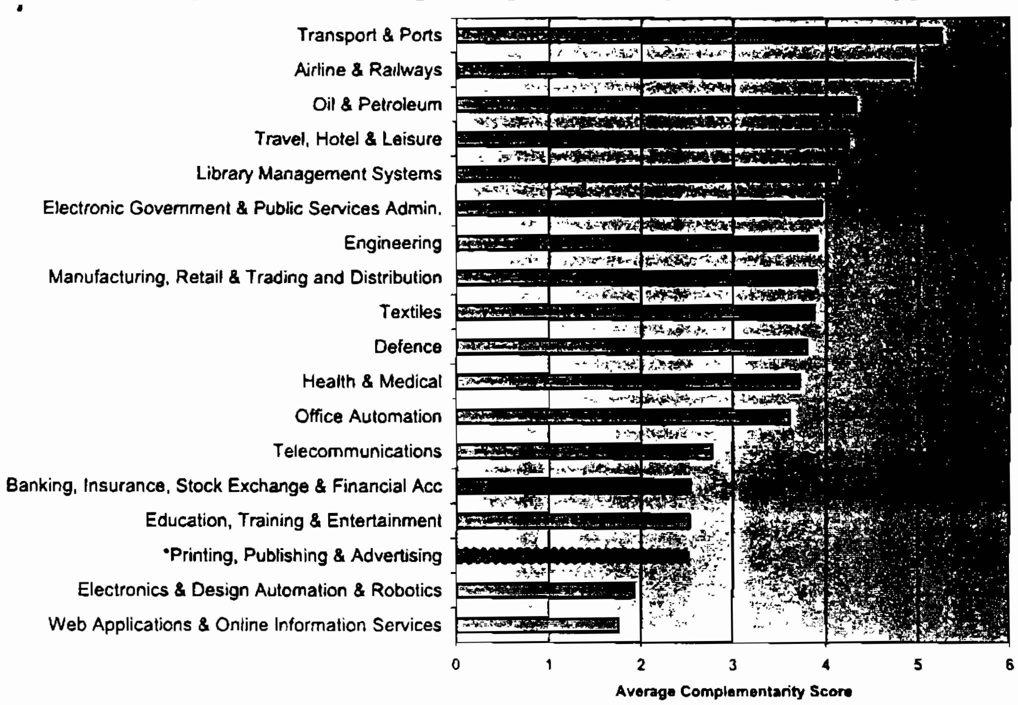
We then computed SRij for these pairs based on probabilities from hyper-geometric distribution. Appendix I gives the complementarity scores for all the 153 pairs of applications. Exhibit 2 shows average complementarity scores[5] of all the applications, which reflects the average propensity to combine specific applications with others. *Transport & ports* has the highest average complementarity and *Web Applications & Online Information Services* has the lowest. This suggests that while the former application has, on average, a very high propensity of getting combined with other applications, the incidence of combining the latter applications with others is low. It needs to be emphasized, however, that high average complementarity scores can coexist with high variance in these scores. But estimates show that skewness[6] of scores is not a problem for most applications (see Exhibit 2, notes).

If one looks at the relatedness scores between two specific applications (Appendix I), one notices that the highest score is for *Transport & Ports* and *Airlines & Railways*. Given the fact that both these applications have very high average complementarity scores (Exhibit 2), these scores indicate that the *Transport & Ports* and *Airlines & Railways* could become a generic combination like *Banking, Insurance, Stock exchange and Financial Accounts* application. In other words, we can disregard the differences between these sectors as the boundaries are increasingly getting blurred.

---

[5] Average complementarity score for each application is a simple average of the complementarity scores of the applications with all other applications.
[6] We relied on skewness because the standard deviation is not a good indicator of dispersion when the kurtosis is high.

Exhibit 2: Comparison of average complementarity scores among applications



Note: Except for Printing, Publishing & Advertising, complementarity scores for other applications are not skewed and hence mean is representative.

V.2. Complementarity among specializations

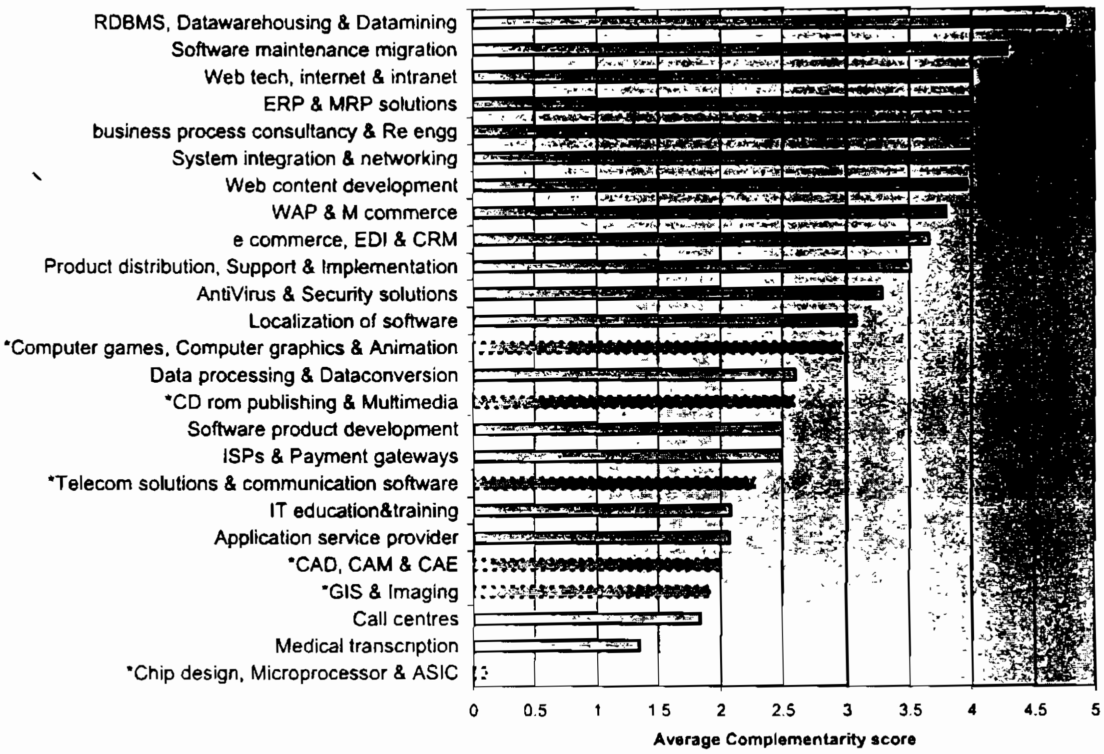
The NASSCOM directory of 2002 consists of 49 specializations and data for 656 firms. However, the information for strongly related specializations has been clustered together, though we have information on the individual specializations also. Consequently, as in the case of applications, the complementarity was found to be very high for the fields within these clusters. We then decided to treat these clusters as single specialization for further analysis to assess complementarity between not so obviously related specializations. The resultant number of specializations was 25.

After elimination of 44 firms with presence in only one specialization, we had data for 614 firms operating in 25 specializations. The total possible number of pairs of specializations amounted to 300. Not a single pair was found with no firm operating therein. The number of firms in specializations pairs varied from 2 to 413.

We then computed SRij for these pairs based on probabilities from hyper geometric distribution. Appendix II gives the details of SRij for all the 300 pairs of specializations. Exhibit 3 shows average complementarity scores of all the specializations. *RDBMS, Datawarehousing & Datamining* has the highest average complementarity. The lower complementariy score alongwith lower number of firms (6% of 656 firms) and high skewness in average complementarity score of *Chip-design, Microprocessor & ASIC* could probably be because these specializations are of very recent origin in India and experimentation with respect to combining this with other specializations has not yet started in any significant manner. The other possibility, of course, is that this specialization is difficult to combine with others due to lack of synergies.

If one looks at the relatedness scores between two specific specializations (Appendix II), one notices that the second highest score is for *Software maintenance migration* and *RDBMS, Datawarehousing & Datamining*. Given the fact that both these specializations have very high average complementarity scores (Exhibit 3), these scores indicate that the *Software maintenance migration* and *RDBMS, Datawarehousing & Datamining* could become a generic combination.

Exhibit 3: Comparison of average complementarity scores among specializations



Note: Except for * cases, complementarity scores for other specializations are not skewed and hence mean is representative.

V.3. Coherence of Indian IT firms

The SRij scores can be used to obtain a firm level measure for coherence. The coherence measure introduced in Teece et al (1994) is a weighted average of relatedness scores. The weights could be either sales or number of employees in each segment. We do not have data on either of these to be used as weights and hence by using un-weighted mean of complementarity scores (SRij) of various pairs of applications and specializations of the firm we can only get an indicative idea of the level of coherence in a firm. For example, if a firm is engaged in *Engineering*, *Oil & Petroleum* and *Trasport & Ports* then the firm's coherence in applications is the mean of SRij scores of *Engineering – Oil & Petroleum, Oil & Petroleum-Transport & Ports* and *Transport & Ports-Engineering*.

The coherence measures for individual companies in the IT industry can tell us whether more less number of applications or specializations is associated with higher coherence. Exhibit 4 shows some interesting patterns. In the case of specializations, the coherence scores tend to decline sharply once a firm has crossed about seven specializations. Interestingly, even with less than seven specializations, the coherence scores tend to fluctuate. However, the mean coherence scores for applications tend to rise almost consistently with the number of applications until the number reaches about twelve and only declines thereafter. One interpretation of these patterns could be that IT firms can retain coherence with large number of applications but not with large number of specializations. Capabilities developed in specific small number of specializations can be applied to a relatively large number of application fields without losing coherence but attempts to straddle large number of specializations may lead to missing out on synergy across capabilities required for these specializations. This result also suggests that knowledge specific to specializations fields is more idiosyncratic than that specific to application fields. Consequently, the potential of knowledge spillovers/synergies across applications is much higher than for specializations. Thus, if a firm wants to increase its coherence it should focus on restructuring the portfolio of applications and in such a fashion that knowledge of a few key specializations is applied to a larger number of applications fields. Exhibit 5 shows the distribution of sample firms by coherence scores for specializations and applications. The distribution suggests that there is scope for improvement in the Indian IT industry. The distribution of coherence in applications and specializations is not biased toward low or high coherence. This means that a substantial majority of firms can improve their coherence scores by restructuring their portfolio of applications and specializations.

Exhibit 4: Mean coherence scores and number of domains

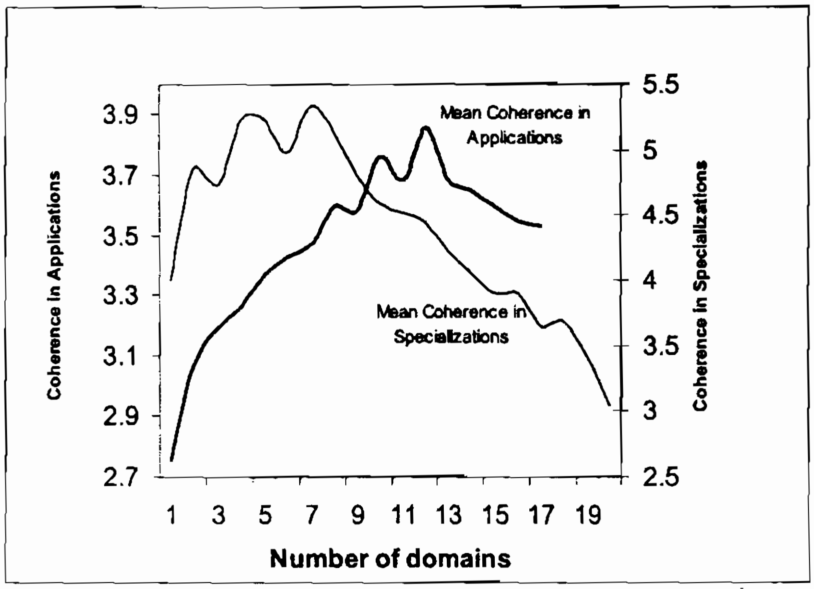
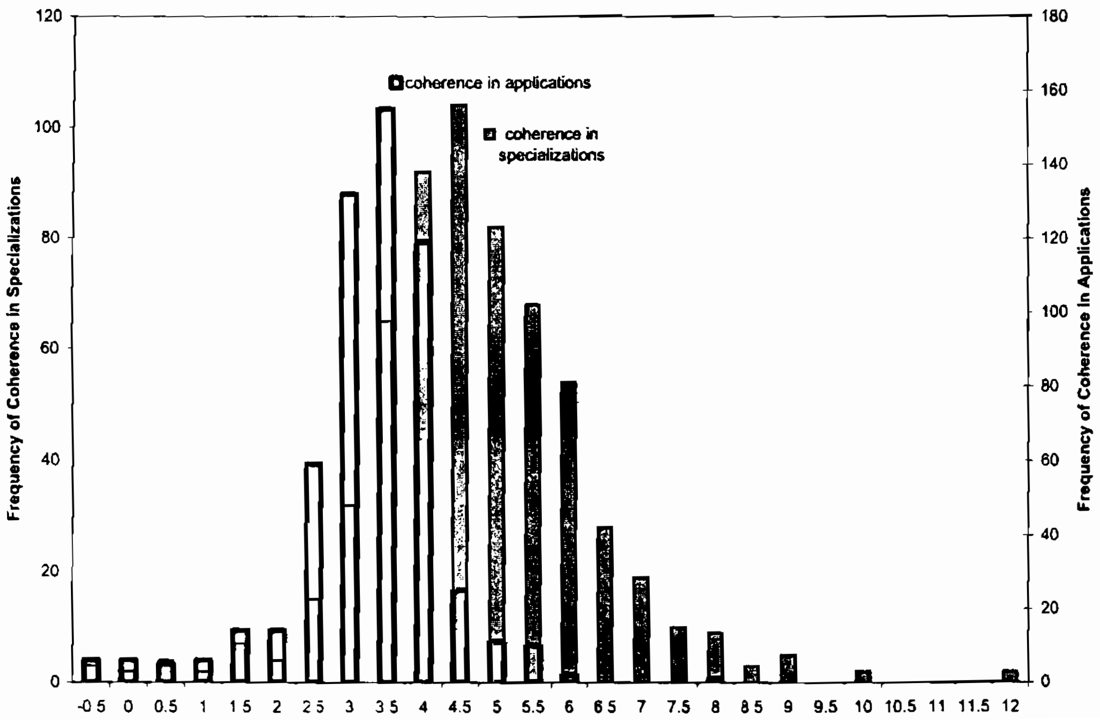


Exhibit 5: Distribution of firms by coherence scores



VI. Managerial implications

A low coherence score indicates that the firm has improper combinations under its ambit. Given the high potential for improving coherence in the Indian IT industry, restructuring the portfolio of applications and specialization has potential to improve coherence of a firm. The results of analysis of complementarity among applications and specializations indicate higher potential of coherence for some applications and specializations. So, a firm can improve its coherence score by divesting the applications / specializations which reduce its coherence and enter those fields which offer higher potential complementarities. The complementarity scores reported in Exhibit 2 & 3 and in the appendices can be used to choose the 'right' application and specialization fields. For example, Samsung Electronics Co. Ltd. India operates only in one application i.e. telecommunication but it specializes in four fields viz. *Telecom-solutions & communication-software, system-integration & networking, software-product-development*, and *Product-distribution, Support & Implementation.* Its coherence score in applications is nil, as it has not diversified into other applications, while its coherence score in specializations is 3.78. The following are the components of its coherence score:

Specialization1	**Specialization2**	**Srij**
software-product-development	Telecom-solutions/communication-software	1.640492
software-product-development	system-integration/networking	4.025292
software-product-development	Product-distribution/Support/Implementation	5.025272
Telecom-solutions/communication-software	system-integration/networking	4.971581
Telecom-solutions/communication-software	Product-distribution/Support/Implementation	1.178753
system-integration/networking	Product-distribution/Support/Implementation	5.766255
	Coherence (Average of the above)	**3.767941**

From Exhibit 3 it is clear that *system integration & networking* has the maximum average complementarity among specializations in its portfolio followed by *Product-distribution,* *Support & Implementation and software product development* in decreasing potential for complementarity[7]. Considering that *telecommunications* is the only application the firm is engaged in, we have to rule out the possibility of dropping *Telecom-solutions & communications* from its portfolio. From Appendix II if we take the maximum complementarity as a criterion, it is clear that among the potential specializations it should enter *software maintenance migration* as it offers maximum potential with its existing specializations, *software maintenance migration* offers highest complementarity with *software product development* (8.21) and *system integration & networking* (5.64). If the new specialization is chosen its coherence score would then increase to 4.40. Similarly, if it decides to diversify into other applications, the best candidate for entry according to Appendix I would be *Transport & Ports*. If it diversifies into any area other than those suggested above then it is foregoing opportunities to maximize synergy with existing knowledge fields.

It also needs to be noted that Samsung Electronics has a higher number of specializations than applications, which might be contrary to the prescription that emanate from Exhibit 4. It is possible that synergies are being derived by the company with its activities in other countries as well as in other industries, Samsung being a diversified MNC. This underscores the caution with which the computed coherence scores should be utilized for strategic decision-making. Contextualization of the strategic options generated from these scores to the firms' specific situation is essential. The point made about the "indicative" nature of these scores also needs to be re-emphasized.

[7] We have not considered the average complementarity score for Telecom-solutions & Communications for comparison because average is not representative because of high skewness (see note to Exhibit 3).

VII. Limitations and future directions

Apart from the limitations noted above, a few more need to be listed. One important limitation is that the survivor-based measure considers only the combinations and not the extent of combinations while computing complementarity/relatedness. The relative proportion of use of knowledge of one field with respect to others would vary from firm to firm which is ignored by this measure. We need to incorporate this heterogeneity for more a valid measure of complementarity. Secondly, lack of data on sales or number of employees makes the analysis of coherence measure an exploratory attempt. Finally, we have used cross section data for computing complementary and coherence scores. These measures are likely to change from year to year and only a longitudinal study of changes in relatedness scores can throw more light on the experimentation behavior of firms in hypercompetitive and dynamic industry like the IT industry. Despite these limitations, these scores can provide a good starting point for any strategic restructuring exercise.

As mentioned earlier the relationship between degrees of coherence and performance is difficult to specify and estimate. Only a longitudinal data can help us explore this relationship in a somewhat rigorous manner. We feel that future work in this area needs to map trends in coherence patterns in the IT industry over time and explore the linkages between changes in coherence score and firm level performance.

References

Ansoff, H. I. (1965). *Corporate Strategy*, 1987 ed., London: Penguin Books.

Berger, P, G., & Eli, O. (1995). Diversification's Effect on Firm Value, *Journal of Financial Economics*, 37, (January): 39–65.

Bhagat, S., Andrei S., & Robert W. V. (1990). Hostile Takeovers in the 1980s: The Return to Corporate Specialization, *Brookings Papers on Economic Activity: Microeconomics*,Pp. 1–72.

Bood, R. (2001). *Images of unfolding diversification projects: charting organisational learning in small and medium-sized enterprises from a cognitive perspective.* - Delft : Eburon, 371 p. Retrieved October 16, 2004 from http://www.ub.rug.nl/eldoc/dis/eco/r.p.bood/

Chandler, A, D. (1962). *Strategy and Structure*, Cambridge: MIT Press.

Comment, R., & Gregg A. J. (1995). Corporate Focus and Stock Returns, *Journal of Financial Economics*, 37 (January): 67–87.

Foss N J & Christensen J F (2001) A market-process approach to corporate coherence *Managerial And Decision Economics*, 22, 213–226

Foss, N. J., & Iversen, M. (1997). Promoting synergies in multiproduct firms: Toward a resource-based view. Working Papers from *Department of Industrial Economics and Strategy*, Copenhagen Business School No. 97-12

Galbraith, J.R., (1983). Strategy and organization planning. *Human Resource Management*, 22 (1/2), 63-77.

Ginsberg, A. (1990). Connecting diversification to performance: A sociocognitive approach. *Academy of Management Review*, 15 (3), 514-535.

Gort, M. (1962). *Diversification and Integration in American Industry.* Princeton: Princeton University Press.

Hunt, S. D. (2000). *A general theory of competition: Resources, competences, productivity, economic growth*. Thousand Oaks, CA: Sage.

Iversen, M. (2000). Synergies and Sustainable Competitive Advantage, Working Papers from *Department of Industrial Economics and Strategy*, Copenhagen Business School, No 00-7

Kaplan, S N., & Michael S. W. (1992). The Success of Acquisitions: Evidence from Divestitures, *Journal of Finance* 47 (March): 107–38.

Kazanjian, R. K., & Drazin, R. (1987). Implementing internal diversification: Contingency factors for organization design choices. *Academy of Management Review*, 12, 342-354

Lien, L. B., & Klein, P. G. (2004). Yet another way of measuring relatedness--this one: let competition do it!, *Academy of Management Proceedings* (pp. F1-F6): Academy of Management.

Miles, R.H. (1982). *Coffin Nails and Corporate Strategies*. Englewood Cliffs, N.J.: Prentice-Hall.

Milgrom P, Roberts J (1995). Complementarities and fit: strategy, structure, and organizational change in manufacturing. *Journal of Accounting and Economics* 19(2–3), 179–208.

Mintzberg, H. (1988). Generic strategies: Toward a comprehensive framework. In: R. Lamb & P. Shrivastava (eds.), *Advances in Strategic Management - Volume 5*, 1-67, Greenwich, CT: JAI Press.

Mintzberg, H. (1990). The Design School: Reconsidering the basic premises of strategic management. *Strategic Management Journal*, 11, 171-195.

Nayyar, P.R. (1992). On the measurement of corporate diversification strategy: Evidence from large U.S. service firms. *Strategic Management Journal*, 13, 219-235.

Patel P, Pavitt K (1997) The technological competencies of the world's largest firms: complex and path dependent, but not much variety. *Research Policy* 26, 141–156.

Penrose, E, T. (1959). *The Theory of the Growth of the Firm*, Oxford: Oxford University Press.

Porter, M E. (1987). From Competitive Advantage to Corporate Strategy, *Harvard Business Review*(May–June): 43–59.

Prahalad C, K, Bettis R. 1986. The dominant logic: a new linkage between diversity and performance. *Strategic Management Journal*, 7, 485–501.

Prahalad C, K., & Hamel G. (1990). The core competence of the corporation. *Harvard Business Review*, 68, 79–91.

Ravenscraft, D, & Scherer, F.M. (1991) Divisional Sell-offs: A Hazard Function Analysis, *Managerial and Decision Economics*, 12, 429–38.

Robins, J. & Wiersema, M.F. (2003). The measurement of corporate portfolio strategy: analysis of the content validity of related diversification indexes, *Strategic Management Journal*, 24, 39-59.

Rumelt, R P (1974) *Strategy, Structure and Economic Performance*. Boston: Graduate School of Business Administration, Harvard University.

Rumelt, R P (1982). Diversification Strategy and Profitability, *Strategic Management Journal*, 3 (October): 359–69.

Stern, I. & Henderson, A.D. (2004). Within-business diversification in technology-intensive industries, *Strategic Management Journal*, 25, 487-505.

Stimpert, J.L., & Duhaime I.M. (1997a). In the eyes of the beholder: Conceptualizations of relatedness held by the managers of large diversified firms. *Strategic Management Journal*, 18 (2): 111-125.

Teece, D. J., Rumelt, R., Dosi, G., & Winter, S. (1994). Understanding Corporate Coherence: Theory and Evidence, *Journal of Economic Behavior and Organization* (Vol. 23, pp. 1-30).

Valvano, S., & Vannoni, D. (2003). Diversification Strategies and Corporate Coherence Evidence from Italian Leading Firms., *Review of Industrial Organization*, 23, 25-41.

Weick, Karl E. (1979) *The Social Psychology of Organizing*. 2nd ed. Random House: New York.

Weick, Karl E. (1995) *Sensemaking In Organizations*. Thousand Oaks, CA: Sage Publications.

Williamson, O. E. (1975). *Markets and Hierarchies: Analysis and Anti-trust Implications*, Free Press, New York.

Zuckerman, E. W. (2000). Focusing the corporate product: Securities analysts and de-diversification, *Administrative Science Quarterly* (Vol. 45, pp. 591-619).

Appendix I: SRij for all the 153 pairs of Applications

Application	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1 Engineering																	
2 Defence	6.46																
3 Health & Medical	3.80	2.21															
4 Telecommunications	3.63	4.51	3.81														
5 Textiles	4.58	4.70	2.71	1.14													
6 Travel, Hotel & Leisure	4.32	2.19	4.85	3.02	4.69												
7 Office Automation	3.54	1.63	3.35	0.09	4.02	5.40											
8 Library Management Systems	4.44	3.36	5.15	0.84	6.17	4.51	8.15										
9 Education & Training | Entertainment	2.35	2.03	3.45	-0.19	2.89	4.09	4.67	4.95									
10 Transport | Ports	5.74	5.89	5.76	7.09	4.43	7.19	4.34	4.60	2.27								
11 Printing & Pulishing | Advertising	2.58	2.03	2.15	1.43	4.66	3.99	2.08	3.10	5.80	2.95							
12 Electronic Government | Public Services Admin.	2.82	6.02	2.97	5.09	5.54	3.37	5.64	3.27	1.86	7.20	2.09						
13 Web Applications | Online Information Services	-0.04	0.03	2.64	-0.43	1.25	2.80	5.27	3.75	0.58	2.81	1.29	2.21					
14 Airline | Railways	4.30	4.96	5.48	5.05	5.06	8.37	4.20	5.52	3.12	8.88	2.20	5.05	1.84				
15 Oil | Petroleum	8.05	7.80	2.84	3.63	5.02	4.50	1.94	3.26	2.03	6.45	2.47	4.80	1.27	6.71			
16 Banking | Insurance | Stock Exchange/Financial Ac	-0.03	1.30	5.62	3.06	1.75	2.55	2.34	3.25	1.06	4.29	1.47	4.57	2.87	4.55	1.73		
17 Manufacturing | Retail | Trading & Distribution	4.51	3.16	4.88	1.84	5.09	5.26	4.31	3.30	2.33	6.01	1.90	5.34	2.80	5.01	4.95	3.98	
18 Electronics | Design Automation | Robotics	5.23	6.28	1.50	3.49	2.03	0.79	0.43	2.09	-0.39	3.28	0.50	-0.80	-0.95	3.42	5.74	-1.27	1.43

Appendix II: SRij for all the 300 pairs of specializations

Specializations	1	2	3	4	5	6	7	8	9	10	11	12	13
1 application-service-provider													
2 software-maintenance-migration	2.86												
3 software-product-development	3.71	5.65											
4 localization-of-software	0.66	5.67	2.64										
5 medical-transcription	0.81	0.38	0.49	0.74									
6 call-centres	1.10	0.67	-1.37	0.32	4.11								
7 web-content-development	3.34	4.58	3.09	5.43	3.23	3.00							
8 IT-education&training	1.29	1.88	1.61	1.74	2.12	3.82	4.68						
9 WAP | M-commerce	3.07	5.64	4.45	4.84	0.16	2.32	3.48	0.16					
10 web-tech | internet | intranet	4.83	9.55	4.39	3.87	1.36	0.36	7.13	1.36	6.44				
11 e-commerce | EDI | CRM	4.10	7.32	4.19	4.16	1.26	3.11	5.61	0.34	8.21	12.63			
12 ISPs | Payment-gateways	4.31	1.95	1.16	1.03	2.71	2.55	2.50	1.18	4.20	3.10	2.56		
13 ERP | MRP-solutions	2.46	9.38	5.39	5.68	1.54	0.48	3.18	1.81	6.99	7.52	7.96	1.50	
14 Telecom-solutions | communication-software	1.91	2.32	1.64	1.22	0.67	1.80	-0.78	1.57	7.05	0.79	0.73	3.92	2.13
15 system-integration | networking	2.87	8.20	4.03	4.22	1.49	2.72	2.84	2.26	4.13	5.26	3.61	3.69	5.74
16 business-process-consultancy | Re-engg	3.88	8.10	4.94	5.93	1.50	3.01	3.03	1.14	4.39	4.95	6.48	1.94	7.44
17 CD-rom-publishing | Multimedia	0.88	1.18	0.38	0.90	2.64	1.06	7.86	5.57	2.52	2.95	0.56	1.22	2.06
18 GIS | Imaging	-1.12	0.76	-0.39	1.24	1.37	0.88	2.88	1.60	0.83	0.49	-0.49	1.43	0.61
19 Data-processing | Dataconversion	1.68	3.16	0.64	3.33	2.72	3.29	7.19	3.07	1.23	1.52	0.37	1.78	1.03
20 AntiVirus | Security-solutions	1.03	3.57	1.50	3.77	-0.26	3.56	3.64	3.31	3.91	2.28	2.73	5.25	4.15
21 CAD | CAM | CAE	-0.03	1.15	0.10	0.05	0.86	0.80	2.07	2.02	1.37	0.70	0.09	1.55	3.15
22 RDBMS | Datawarehousing | Datamining	3.42	12.31	5.24	5.44	0.44	2.51	5.84	1.67	6.73	11.04	9.65	3.08	9.79
23 Product-distribution | Support | Implementation	2.95	5.26	5.03	7.07	-1.11	2.97	4.64	4.90	3.86	3.19	2.62	2.60	5.06
24 Chip-design | Microprocessor | ASIC	-0.37	-0.87	-0.57	1.27	0.30	-0.27	-0.81	-1.47	1.29	-2.44	-2.57	2.02	-0.79
25 Computer-games | Computer-graphics | Animati	0.12	1.99	2.13	2.56	2.78	1.30	7.43	2.38	3.88	2.78	2.61	2.50	1.76

Appendix II: SRij for all the 300 pairs of specializations (cont'd)

	Specializations	14	15	16	17	18	19	20	21	22	23	24
1	application-service-provider											
2	software-maintenance-migration											
3	software-product-development											
4	localization-of-software											
5	medical-transcription											
6	call-centres											
7	web-content-development											
8	IT-education&training											
9	WAP | M-commerce											
10	web-tech | internet | intranet											
11	e-commerce | EDI | CRM											
12	ISPs | Payment-gateways											
13	ERP | MRP-solutions											
14	Telecom-solutions | communication-software											
15	system-integration | networking	4.97										
16	business-process-consultancy | Re-engg	2.19	6.95									
17	CD-rom-publishing | Multimedia	1.44	1.46	1.35								
18	GIS | Imaging	1.92	2.44	0.58	3.30							
19	Data-processing | Dataconversion	1.38	2.78	2.67	4.30	5.83						
20	AntiVirus | Security-solutions	2.85	6.32	5.97	2.64	3.10	1.59					
21	CAD | CAM | CAE	2.60	2.11	1.80	3.57	10.52	3.79	3.32				
22	RDBMS | Datawarehousing | Datamining	1.47	7.05	8.37	1.31	1.35	4.84	3.69	2.04			
23	Product-distribution | Support | Implementation	1.18	5.77	6.32	1.48	2.69	2.62	6.87	0.98	5.64		
24	Chip-design | Microprocessor | ASIC	6.50	2.00	-0.09	-0.07	-0.61	-1.44	1.36	0.14	-0.46	-0.02	
25	Computer-games | Computer-graphics | Animati	3.03	2.43	2.48	11.63	4.53	3.07	2.54	3.07	1.65	1.82	0.51