Alliances in Large Emerging Economies:

Evaluating R&D-specific Factors of Biotech Firms

Type of paper: Competitive

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Abstract:
In this study, the role of R&D-specific factors in determining the feasibility of strategic alliances between SMEs from developed countries and SMEs from large emerging economies (LEEs) is examined. The empirical data was collected by identifying R&D-specific factors associated with biotechnology SMEs from the UK and Germany in the context of possible alliance formation with their counterparts in Brazil. Two groups of firms are characterised for comparison, the most compatible and the least compatible firms. Our findings show that R&D-specific characteristics impact upon the compatibility of firms contemplating strategic alliances. In particular, firms showing a strong innovation history, in general, are found to be more compatible with LEE firms than those that do not. Another important R&D-specific characteristic is the firm's searching and identifying capabilities relative to technology or equipment that show good prospects to improve the firm's line of products. Implications for policy-makers and practitioners are also discussed.

Keywords: alliances, R&D-specific factors, Emerging Economies

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Introduction

Emerging Economies, in particular those associated with large potential customer bases such as China, Brazil, India and Mexico, i.e. Large Emerging Economies (LEEs), are increasingly important in the Global Economic Environment. Foreign Direct Investment flows have increased substantially into LEEs, and this trend is expected to continue (UNCTAD 1998 and 2000). An important aspect of this trend is firms from developed countries forming alliances with indigenous firms in the LEEs. Foresights suggest that these economies are not only expected to be home for a substantial number of the world's largest enterprises in the next 20 years, but also the economic centre of gravity of the world will shift towards these countries (Govindarajan & Gupta, 2000). This trend is expected to speed up in the coming years due to the fast relative growth of the economy of the developing versus developed countries, the strategy of firms trying to secure first-mover advantages in emerging markets, the potential for economies of scale, and the benefits of locational advantages.

This paper focuses on the R&D characteristics that are associated with Small and Medium-Sized Enterprises (SMEs) in developed countries (United Kingdom and Germany) and their compatibility to alliances with SMEs in LEEs. Our study is expected to help both practitioners and policy-makers to examine the association of R&D characteristics and its effect upon the chances of a successful partner selection stage of International Strategic Alliances (ISAs) between developed country firms and their counterparts in LEEs.

The literature regarding the confluence of non-developed countries and technology is usually limited to low and medium technology initiatives, or focuses on one or two "in fashion" countries (e.g., for Chinese high-tech ventures see Li & Atuahene-Gima 2001; and Bennet et al. 2001). However this does not seem to truly reflect the reality as current trends of FDI in LEEs include areas of high-technology. Emerging economies, in particular in Latin America, are expected to show a strong technology driven growth (Simos 2000). In a survey sponsored by Fleet-Boston Financial more than 50% of 200 senior multinational executives indicated technology and telecommunications sectors as propelling Latin America's growth over the next four years (cited in America's Network 2000). Regional high technology science parks are expected to attract a large number of these investors in emerging economies, as in the case of Campinas in Brazil (Business Week 1998).

Indigenous R&D policies are expected to determine the attractiveness of regions in emerging economies to high-technology potential partners from developed industrial countries, particularly in those regions with large markets. It has been suggested however that only the transfer of appropriate technology would supplement the development policies of LEEs (Rustagi 2001). In this context it is important for policy-makers and entrepreneurs of both developed countries and LEEs to examine the issues affecting high-technology sectors. For instance, in designing the appropriate business environment associated with a certain technology, policy-makers should examine in depth the needs and expectations of foreign companies wishing to operate in a specific sector. This information would also be valuable for local as well as foreign executives and entrepreneurs working in that sector.

Biotechnology is one of the areas which policy makers in these LEEs are particularly enthusiastic about. This enthusiasm stems from the expected high demand for biotechnology products and services in these countries. Modern biotechnology, normally associated with genetic engineering, came to prominence at the end of the last century as promising an unparalleled technological revolution for humanity (OTA 1984; EU White Paper 1994). Although well advanced in developed countries, this biotechnological revolution has only recently started to reach emerging economies.

International Strategic Alliances (ISAs) is one way for companies of advanced industrial economies to pursue very promising business opportunities associated with the large markets for biotechnology products of LEEs. Several authors have pointed out the escalating role of ISAs in the today's international economic environment (Dunning 1997; Lorange & Roos 1993; Hennart 1988;

Shan, Walker & Kogut 1994; Raveed & Renforth 1983; Buckley & Casson 1988; see also De Mattos 2001). ISAs can accelerate the process of transfer and adaptation of advances already reached in developed countries, as well as fostering the development of new products and processes. This is particularly important when considering that biotechnology could potentially solve humanity's major problems, many of which are concentrated in developing countries.

In the next section literature on Brazil and R&D characteristics that determine the propensity to enter into transnational alliances and joint ventures is discussed. Next our methodological approach to the data-collection is presented. In the following section we analyse our data. A variety of statistical techniques are used to aggregate the variables into factors and to carry out a discriminant analysis of these factors. This is followed by the presentation of our findings, and finally by the conclusions.

Brazil

Brazil could be seen as representative of other LEEs (e.g. China, Mexico, India and Poland) for high technology, in general, or biotechnology in particular. Probably because Brazil's legislation was only modified to allow patenting of genetic engineered micro-organisms in 1997, the country does not have a substantial number of alliances connected to modern biotechnology (De Mattos et al. 2001). However, the inflow of foreign investments in this area has increased substantially since 1997, particularly associated with large companies such as Monsanto, Hoechst-Schering, Dow Chemical and Du Pont (Chemical Week, Apr 21, 1999; Aug 16, 2000). This trend is expected to continue as Brazil joins the international development of this promising scientific area. Small and Medium-sized Enterprises (SMEs) as well as larger companies are expected to contribute and benefit from this trend. The more formal recognition of Intellectual Property Rights (IPRs) in LEEs is expected to attract more Foreign Direct Investment (FDI) to those countries, particularly FDI involving high-technology (Mansfield 2000; Maskus & Yang 2000). Brazil and its recent legislation relative to pharmaceutical patents (including biotechnological products) are part of this picture. IPR legislation is expected to act as an incentive for the internal development of this technology, or its adaptation to the local market (World Bank 1998).

The previous paragraphs have indicated the upsurge in activity of ISAs in the biotechnology area of a LEE, Brazil. Clearly studying aspects of this phenomenon is intrinsically important. However, this importance is amplified by the scarcity of published work in English about Brazilian business and even less about ISAs in Brazil. This study particularly focuses on the impact of R&D-specific factors on alliance formation since for high technology R&D is an important, if not the major, consideration.

The Biotechnology sector in Brazil

Intermediary[1] biotechnology in Brazil is well advanced in Universities, as well as in private and governmental Research Centres. Some genetically modified products are expected to reach the market very soon as Brazil and other Latin American countries adjust to changes in patent regulation that affect the biotechnology sector (Cunningham 1999).

Brazil is the world's largest producer of coffee, second largest producer of Soya beans, and the world's third largest producer of corn (Chemical Week Jul 31, 1999; Aug 16, 2000; Nov 1, 2000), and therefore has an enormous potential market for agricultural biotechnology products. The country also presents a very high potential for growth in other biotechnology areas, for instance Brazil is expected to become the fifth or sixth largest pharmaceutical market in the world by 2010 (CODETEC 1991, p.67). The potential for growth is also large considering that the consumption per capita in a developed country reaches US$ 110/year, and that figure in Brazil is less than US$14/year in the early 1990's. This would place Brazil as one of the three potentially largest emerging markets for pharmaceuticals in the world (De Mattos 1999).

The firm's R&D characteristics and their influence on internationalisation

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Notes

[1]Traditional Biotechnology with intermediary techniques utilises advanced knowledge of genetics and biology (but no genetic manipulation).

The literature associating the R&D characteristics of firms with their respective internationalisation strategy is limited. Traditionally such studies where they do occur focus on Multinational Corporations (MNCs) in particular large companies and ignore SMEs. Buckley & Casson (1979) point out that skilled labour availability usually determines the location of R&D of an MNC. The lower cost of skilled labour in LEEs relative to developed countries, and its availability nearby high technology science parks jointly fostered by governmental agencies and private initiative in LEEs could perhaps explain the upsurge of high technology investments in these countries. According to Stopford and Wells (1972) firms oriented towards R&D will tend to utilise local partners the more their line of products is diversified. This argument seems to be implicitly associated with large established MNCs. Telesio (1988) has also associated firms having high R&D expenditure with the tendency of not utilising a wholly owned subsidiary. The author suggests that new technologies can make the oldest obsolete, the latter becoming appropriate to licensing or, by extending the argument, to strategic alliances.

Other factors deserve attention. Ransley & Rogers (1994) report that four respected consulting firms examined best research and development (R&D) practices, each with their own objectives, methods, and scope. Presumably, those R&D practices that are common among these studies can be taken as valid and should have broad applicability. Looking for agreement in those studies, Ransley & Rogers identified a few best R&D practices and explained as follows: (1) The use of technology strategies. There was unanimous agreement on the need for strong alignment of the technology strategy with the corporate and business strategy. This requires clearly articulated statements of mission. The role of technology will be incorporated into the specific business goals and communicated clearly to all functions. This was seen as probably the most important issue for the technology manager. (2) Integrating all functional areas around a programme. This would involve cross-functional teams including marketing, manufacturing and sales. The aim would be to link ultimately technology programmes with customer satisfaction. These authors suggest that a high performance would lead to an effective integration in terms of shared priorities, timetables and concern over unexpected events or outcomes. (3) Also cited as important is the identification and strengthening of the firm's capabilities around core technologies. This would be accomplished in alignment with the overall firm's strategy. (4) Monitoring of technology threats and opportunities on a world-wide basis. This should incorporate multiple sources including customers, suppliers, the competition, universities and research centres, and governmental agencies among others. The authors point out that special attention should be placed on developing relationships with these organisations. In addition they profess that "alliances for joint technology development can be an important aspect of an external awareness system, while levering limited technical resources". (5) With regard to technology transfer a diverse approach should be used such as cross-functional teams, communication/linkages across divisions, businesses and functions, and temporary assignments/rotations. (6) Finally, the personnel strategy should be integrated with the long term R&D strategy. There was agreement on issues such as recruitment, career development, and matching skills needed.

Research Question and Methodology

In this study, we explore whether or not it is possible to identify R&D-specific factors of a developed economy high-technology partner-firm according to the degree of compatibility of firm relative to a prospective alliance with its counterpart in a LEE. In trying to answer this question a proxy for compatibility was used. Developed-country firms were differentiated based on the expectations and perceptions of their managers towards the alliance's partners contributions. Thus a pragmatic definition of 'compatibility' is adopted here; it is based on quantifying the match of expectations held by executives regarding their firms' potential contributions to a prospective alliance. We use four possible perspectives regarding the partners' respective contributions to the alliance to identify two groups of firms – the "most compatible" and the "least compatible" (see De Mattos et al. 2002).

The R&D-specific characteristics of both groups are then analysed. Proxy variables for a number of the R&D characteristics identified in the previous section were empirically developed through the design of the questionnaire in this study. Our focus is to identify the R&D characteristics that discriminate between these two groups of firms. The final objective is to determine those characteristics that are associated with the group of firms "most compatible" to ISAs in LEEs.

Data Collection

This study was limited to firms operating in the biotechnology sector of two developed countries, namely the United Kingdom and Germany. These two countries are considered to be home for most advanced developments of European commercial biotechnology developments. The sample comprises firms directly developing biotechnology as well as firms supporting that activity as suppliers of reagents, equipment, and software. In our study Brazil was assumed as representing LEEs, and the prospective nature of the research is underlined by the fact that most of the firms sampled have not established at the time of the survey any business contacts in that country. The British firms were located mainly in the South of England, while the German firms come from three regions that are known to present a high concentration of firms in the biotechnology sector: Berlin, Dusseldorf and the Munich areas[2]. Approximately 80 firms were sampled at random from two directories --Bio Technologie (1996) and Coombs and Alstn (1996). Approximately 65% of the firms contacted by fax and telephone agreed to participate in the survey.

The data examined in this study were collected by means of questionnaires completed during face-to-face semi-structured interviews. Open and closed questioning was applied, and all interviews were recorded. The questionnaire was designed from the literature and addressed the main issues relative to identifying R&D specific variables. Two pre-test interviews were conducted, which showed that only slight alterations to the survey instrument were necessary.

A total of 71 firms were visited, and one executive was interviewed in each firm. This comprises interviews with 28 British firms, 25 German firms and 18 Brazilian firms. Most of the interviewed executives held the position of managing director.

[2] The Brazilian firms were located in the Brazilian states of Rio de Janeiro and Sao Paulo. These firms were associates of the only national biotechnology association in existence at the time of the survey.

Data Analysis

In order to support the analysis proposed in this study, the developed country firms were categorised into two groups. Each European executive's response was related to the average of the Brazilian executives' response regarding the importance of potential contributions made by partners to an alliance (please refer to Figure 1)[3]. This was used as the basis for separating the sampled firms into the "most compatible" and the "least compatible" groups. By considering the coefficients of Spearman rank correlations, two groups of 20 firms each (out of the 53 European firms) were classified as being "most compatible" (those having the higher coefficients) and "least compatible" (those having the lower coefficients). It is presumed that the firms at each extreme of the range of "compatibility" would better represent the characteristics associated with each one of the groups.

Insert here Figure 1

Next, the R&D characteristics of these two groups of European firms are examined. The objective is to identify R&D characteristics, aggregated into variates or factors, that differentiate between the two groups of firms. In particular, it is sought to identify those characteristics associated with the "most compatible" group of firms. First variables are selected for factor analysis, used here just as an indicator of shared common variance among variables that are then grouped together. The aim at this stage is to reduce the number of working variables by grouping them into a smaller number of representative variates. The variates are composed of a number of variables connected to R&D-specific characteristics (for specific variables, please refer to Table 1) built on the basis of equally weighted standardised scales[4]. These factors or variates[5] are then used to perform a discriminant analysis that identify the relative importance of those variates.

[3] A six point Likert scale was used to quantify the partners' expected contributions to a prospective alliance.
[4] An adaptation of summated scales deriving from factor analysis proposed by Hair *et al.* (1998, pp.129-131).
[5] Factor and variate are used interchangeably throughout the paper

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Insert here Table 1

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Note: All metric variables were categorised prior to the calculation of Chi-square.

Thus, following the overview of the methodology, the authors will now detail the analysis carried out. Initially, 28 variables were reduced to 25 by choosing those showing more potential to discriminate between the two groups of firms. In the selection of appropriate variables the Pearson Chi-square and the variable type (metric versus categorical) were considered. A Pearson Chi-square greater than 1 was used to indicate a reasonable potential for differentiation by the specific variable under consideration.

Next, an exploratory factor analysis was performed to further reduce the number of variables. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy and the Bartlett Test of Sphericity were applied and confirmed the applicability of the factor analysis (the KMO in the acceptable range of above 0.50, and Sphericity = 607, Significance < 0.0001). The variables were then grouped into a number of variates, representing the dimensions underlying the data set under examination. The coefficients of the factor analysis were used as indicators of which variables should be grouped into each variate. The variables associated in each variate were then standardised and the reliability of each set of variables were confirmed using Cronbach alpha and modified, if necessary[6]. An interactive method was used in which any variable that, if omitted in a particular round test, would increase alpha was deleted, so reaching the maximum possible alpha for any factor. The highest Cronbach's alpha for each factor is shown in Table 2 together with the variables that were selected.

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Insert here Table 2

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[6] By considering the Cronbach Alpha some variables were taken out of the variates.

The above procedure grouped nineteen selected variables into six variates or factors. Using an interpretative approach, each factor was assigned a meaning. A Kolmogorov-Smirnov test was used to confirm the univariate normality fit for each modified factor, yielding a univariate normality fit within a 5% level of significance.

Finally, a discriminant analysis with the modified factors was performed, and both its significance and its hit ratio were analysed. The results of this analysis are presented below. Three key assumptions were evaluated prior to the discriminant analysis: multivariate normality of the independent variables, i.e. the six variates; equality of covariance matrices for the groups under analysis; and the absence of collinearity among variates. The risk of multicollinearity was minimised through the use of varimax rotation, due to its orthogonality. The hit ratio is taken as one of the main validators of the discrimination process; i.e., the higher the number of firms correctly classified in their original group, the more reliable the process is. In addition a simultaneous estimation was used. The small number of factors involved, six, does not make stepwise estimation appropriate as data reduction was accomplished previously by factor analysis.

The final hit ratio (or classification accuracy) of 77.5% is good[7]. The slightly better accuracy of the discriminant function with regard to the "most compatible" (85%) group of firms when compared to the "least compatible" (70%) could be interpreted as giving added weight to the characteristics of the "most compatible" executives.

An independent measure of accuracy of the discriminant function is given by the intermediate group of firms. Applying the discriminant function to the 13 intermediate cases

[7]The probability of correctly classifying by chance would be 50%, as the number of cases (20) are the same in each group. Hair (1998, p.269-70) suggests that the classification accuracy should be at least 25% greater than that achieved by chance, in this case 62.5%.

initially left out of the analysis[8], eight were correctly classified (80%), which indicates a strong reliability of the analysis.

Results and Discussion

The role of each variate in differentiating between 'most' and 'least' compatible firms in decreasing order of importance is indicated by the loading in Table 2[9]. The first variate (V1) denotes the innovative history of the firm. It is composed of only one variable (var.8) as listed in table 1, due to its much higher discrimination power when compared to other variables, and its low correlation with other variables. The low reliability that this variable produces in a factor was also considered. The variate associated with the recent innovative history of the firm (V1) shows the highest discrimination power among the three factors with the highest loading (0.8). This variate was generated from the variable representing the number of new products developed during the three years previous to the survey (var.8), which originates in the 'Technology Generation / Transfer' activities data set. This variate is composed of only one variable due to the much higher discrimination power of this variable relative to other variables in the set, its low correlation with other variables, and also the low reliability it yields when associated with other variables in the data set. However the relationship does not follow the pattern that one might expect, that is, the greater the number of new products the greater the compatibility. The "most compatible" firms are mostly firms that developed only one product, that is, "one product in the last 3 years". This would indicate a much-focused effort around one specific product or line of products. The specialisation in some specific product or technology could lead to a drive for excellence at that respective area. In principle this appears to indicate a pattern unsuited for large established Multinational Corporations

[8] It is assumed here a different categorization. The "most compatible" group of firms is composed of those firms that show the higher coefficients of compatibility, that is the higher half. Similarly, the "least compatible" group would show the lower coefficients, that is the other half. One firm would be left and considered non-categorized.

[9] The loading is preferred rather than the coefficient to indicate the importance of the factor in the discriminant function (after Hair, 1998). The discriminant loading – that is, the correlation between the factors and the discriminant function – reflects the shared variance between the discriminant function and the independent variables. Its square represents the amount of function total variance accounted for by the factor. It is assumed that the factors' respective loading translate their level of importance in discriminating between the 'most' and 'least' compatible group of firms.

(MNCs), as well as for very small one firms, as the former would maintain numerous product lines, and the latter would not have any products of its own. In addition, the concentration in one line of products would denote a higher scarcity of resources when compared to MNCs, and consequently would be expected to influence the choice of product strategy.

The second variate in importance of discrimination is searching and identifying capability (V2). This variate's coefficient is slightly more than half of that for the first variate. This variate is composed of 4 variables, as shown in table 2. Two of these variables are connected to the awareness of technologies or equipment that could improve the present line of products of the firm (var.12, var.13), and the other two represent the number and EU membership of countries that could potentially supply that technology or equipment (var.14, var.15). Independently, any one of these variables does not have significant discriminatory power between the groups. However, if they are re-coded into three or four ranges or categories, the "most compatible" firms show a tendency to cluster on lower and medium values, whereas the "least compatible" firms present higher values. This explains the negative sign of the coefficient. The “most compatible” firms are clustered in “one” technology or equipment rather than either in “none” or “2 or more”. This strengthens the idea of the focus of efforts around one line of products, along with the higher potential for excellence on that particular choice. The “least compatible” firms are associated with a higher number of technologies that could improve the firm’s line of products. This seem to strengthen the previous result suggesting and association between compatibility and "one" technology or equipment. This also seems to contradict the findings of Stopford and Wells (197?). It indicates that SMEs will follow slightly different patterns than large MNCs.

By examining the number of countries with potential for providing the technologies, a very similar distribution of EU and non-EU countries may be seen. There is a concentration of values in the middle range. This strengthens the previous observation of the tendency towards specialisation, and of resources focus. All of the above points seem to indicate the need for the development of instruments that would allow the identification and assessment of technological focus in a firm or group of firms.

The third variate (V3) may be seen as a measure of the firm's preparation for the future. This may be interpreted through the variables concerning the awareness of other obstacles than cost in obtaining technologies or equipment (var.17). This variate is composed of two dummy variables connected to the same original variable. This arises through the variable representing the awareness of obstacles in connection to acquiring technologies or equipment that could improve the firm's present line of products. The replies of the "least compatible" firms seem to cluster on "cost factors", whereas the "most compatible" firms tend to point to "other obstacles". It seems reasonable that "cost factors" would be brought up by Managing Directors (MDs) who had not yet given much thought to the possibility of acquiring technologies or equipment overseas. In contrast, better prepared MDs would have already examined this possibility in greater detail and would have identified obstacles other than cost, either by reflective thinking or experience. These executives may be said to be better prepared, having progressed further in the process of learning to expand, or in the firms' preparation for the future. HERE Although this variate has the lowest coefficient in the discriminant function it may not be taken out of the function, lest some decrease in the hit ratio, This factor however do not present a strong discrimination power and the function significance is to occur. They may be explored further in other studies more focused on specific dimensions.

The three other variates[10] were not included in the discriminant analysis due to their adverse influence on the hit ratio and the significance of the discriminant function. The three factors taken

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[10] The fourth factor (F4) groups variables that may be interpreted as relative to the Firm's magnitude of R&D resources, that is, R&D expenditure in 1996 (var.20)[10], the average R&D expenditure over 1994-1996 (var.21), and finally the estimated R&D expenditure over the next 3 years (var.23). The fifth factor (F5) groups variables relating to what may be seen as the firm's technological capability. This may be interpreted from the variables relative to the time periods involved in the development of a product line (var.6, var.9), the holding of patents (var.18, var.19), and finally the level of expertise of the firm in its field as perceived by the senior executive interviewed (var.27). The sixth factor (F6) groups variables which could be interpreted as representing the firm's innovation drive. This variate comprises variables relative to the number of products developed by the firm, or obtained externally (var.1, var.3 , var.4) , and the percentage of R&D expenses covered by government funding (var.26). As one might observe the variables related to obtaining the technologies or equipment externally have a negative coefficient indicating an opposing variability to the underlying common dimension of the factor.

out of the discriminant function could be explored further in other studies however in tis study they do not seem to help in differentiating between the "most" and the "least" compatible groups.

Each factor will be explained and commented on in order of decreasing importance. Both the functions' coefficients, and the loading for each factor are shown in table 2. Furthermore, it is assumed that the factors' respective loading translate their level of importance in discriminating the "most compatible" from the "least compatible" group of firms. The function is significant at a 5% level. The factors are divided into two groups: first, the ones presenting strong explanation power (more than 20%) which comprises 'innovation history' and 'searching / identifying capability'; and second, the ones presenting a medium explanation power (more than 5%, less than 20%), that is 'preparation for the future',

The latter group should be examined carefully as, although not strongly explaining the function's variance, they might shed light into dimensions that could prove reasonable reflections of reality. These could possibly be further examined by more focused surveys.

Conclusions

Three factors reached high and medium explanation power relative to R&D-specific characteristics as illutrated in Figure xx, namely: (a) Innovation History: This factor discriminates the most between the two groups. It is associated with the recent innovation history of the firm. It was observed that the "most compatible" are mostly firms that have developed only one product in the last 3 years. This seems to indicate a very focused effort around one specific product or line of products. In principle, it could also be indicative of a pattern away from established Multinational Corporations (MNCs), as well as from very small ones, as the former would maintain numerous product lines, and the latter would not have any products of its own. In addition it would denote a higher scarcity of resources when compared to MNCs, and consequently the influence in the choice of product strategy. (b) Another factor of strong explanation power is Searching and Identifying Capability. It is interesting to note that the "most compatible" are concentrated in one technology or equipment rather than either in none or 2 or more. This strengths on one hand the idea of the focus of efforts around one line of products, and the higher potential for excellence on that particular choice. Moreover the number of 'sought for' technologies are more spread, i.e. present a higher deviation, in the "least compatible" group of firms. By closer examination of the latter variables it is to note a tendency of indicating either 1 or no EU countries by the 'most compatible' group of firms. This would show once again a concentration in one specific technology rather than in "2 or more". This strengthens the previous observation of the tendency towards specialisation, and of resources focus. All that has been noted above seems to indicate the need for the development of instruments that would allow the identification and assessment of technological focus in a firm or group of firms. (c) Finally a factor of medium explanation may be seen as a measure of the firm's preparation for the future. This interpretation arises through the variables representing the awareness of obstacles in connection to acquiring technologies or equipment that could improve the firm's present line of products. The "most compatible" firms would be associated with more experienced (or reflective) executives who would tend to identify obstacles other than costs to acquiring technologies or products to improve their firm's activities. These executives may be said to be better prepared, having stepped further in the process of learning to expand, or in the firms' preparation for the future.

In sum, it was possible to identify R&D-specific factors that discriminate between the two groups of firms, the "most" and the "least" compatible. It is expected that these results call attention to, and foster discussion over a few previously unsuspected points that seem to influence the firms compatibility to alliances in LEEs. Moreover it is expected that this initial study has added to the efforts to foster biotechnology alliances between firms in LEEs and developed countries. This should open avenues for developing countries, in general, to participate in the development of this vital technology.

Limitations of the Study

Any generalisations should taken into consideration the following features of this study: (a) Although the sample consists of SMEs operating in the biotechnology sector, it comprises firms with different and sometimes multiple, activities (e.g. production of reagents, instruments, software, and biotechnology research). As a common ground all firms, directly or indirectly, are involved in the development of one or more biotechnology products. These firms may however possess specific characteristics connected to its area of expertise; (b) It is expected that the results could be better generalised to LEEs, such as Mexico, Russia, India , and China; (c) The perceptions collected were focused on the "time of entry" in an unfamiliar emerging economy as most respondents had never had any business contacts in Brazil; (d) The focus was on firms operating in the area of biotechnology. The biotechnology sector has its own dynamics with an intense interplay between SMEs, Research Centres, and Established Large firms. This might not hold true with regard to other sectors. (e) The study used subjective measures. More objective measures may help in exploring further some indications which appeared here;

In this study an exploratory approach was used. As a consequence the results only indicate possible paths, that should be examined through confirmatory research.

Managerial and Policy Implications

All limitations are important and should be considered when extrapolating results of this study to other situations or countries. Executives should consider that these findings represent a picture of a moment. Understanding these results on the light of the associated background might bear fruits at the time one extrapolates the findings to similar situations.

Based on results of the "most" compatible firms, the Brazilian market, most probably due to its size, would need a great commitment of resources on the part of an SME. As a consequence this would not allow, at least in the initial moment, the targeting of global or other regional markets, lest through partnerships in different markets. Alliance strategies would permit this multimarket approach.

The category of "least" compatible firms does not mean it is not possible for those firms to pursue strategies of alliances with firms located in the emerging economy. However such a group of firms will no doubt have a specific agenda of needs and contributions, and it could take a much longer time to align the needs of both sides. In order to explore fully business opportunities with firms of developed countries, entrepreneurs in LEEs should seek pro-actively opportunities. This strategy could also be pursued towards other LEEs particularly those on the avenue of industrialisation, such as in Eastern Europe and the Far East.

Policies concerning Science & Technology, aiming at accessing the knowledge base of other countries, such as those encouraging strategic alliances and the participation in international programmes of scientific co-operation, should also consider the characteristics of the firms that are targeted by their programmes. For instance, attracting the "right" firm could increase the success rate of international alliances.

Suggestions for Future Research

First the scope of the firms associated with biotechnology could be measured down to a specific activity. Considering the heterogeneity of the sample, that is firms connected to a broad range of activities within the biotechnology sector, further studies focusing attention on one specific activity (e.g. instruments) could possibly highlight the characteristics, or needs, associated with that particular group of firms. Also, differences in stage of development of the industry, geographical location, and culture could help to understand, and consequently, to promote alliances in biotechnology;

Expanding the idea mentioned above it would seem very promising a comparative analysis of government policies affecting biotechnology of LEEs in different regions, such as for instance in Brazil, Poland, and South Korea. A similar analysis was undertaken focusing however only on developed countries (refer to Bartholomew 1997). Another possibility of expansion of this research would be to other industries. In particular comparative studies focused in other high technology areas could provide some insights: (a) on how to generalise results across sectors, (b) and to identify and understand the common features across sectors;

Further research using quantitative surveys is deemed necessary to confirm the findings. Alliances among LEEs firms, particularly those advanced in the industrialisation process, provides a natural expansion for this type of research. This is also the case of multilateral alliances in which partners could be from both developed and emerging economies. It would be valuable to perform similar research in other LEEs, as well as in other developed countries.

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Table 1: Variables connected to the R&D Characteristics

Category	Description	Var.	Chi-square	Sign.	DF	Type
Technology Generation / Transfer	No. of new products developed in the last 3 years	1	7.03	0.01	1	m
	No. of lines of products developed by the firm	2	5.76	0.12	3	m
	No. of technologies or equipment as above	4	3.13	0.07	1	m
	No. of patents	8	2.03	0.36	2	m
	No. of EU countries as potential suppliers of above	9	1.88	0.38	2	m
	Holder of patents	10	1.75	0.18	1	c
	Obstacles for acquisition of above	11	1.67	0.19	1	m
	Maximum duration among projects of New products	12	1.31	0.51	2	m
	Technology or equipment for improvement of products	13	1.11	0.29	1	c
	Development of New products / processes	14	1.02	0.31	1	c
	No. of non EU countries as potential suppliers of above	15	0.78	0.67	2	m
	No. of EU countries suplying product lines	16	0.62	0.73	2	m
	Average delay on the development programme	17	0.61	0.43	1	m
	Time of existence of R&D sector	19	0.55	0.75	2	m
	Average time of development of a product line	20	0.53	0.76	2	m
	Specific / Separated R&D sector	23	0.40	0.52	1	c
	USA is a potential supplier of above	24	0.40	0.52	1	c
	No. of non-EU countries suplying product lines	25	0.29	0.86	2	m
	No. of lines of products obtained from external sources	27	0.16	0.91	2	m
Financial Support	Percentage increase average next 3years over last 3 years	5	2.85	0.23	2	m
	Average R&D expenditure estimated for next 3 years	7	2.26	0.32	2	m
	Average R&D expenditure 1994-1996	18	0.57	0.75	2	m
	R&D expenditure over Turnover 1996	21	0.48	0.78	2	m
	R&D expenditure 1996	22	0.47	0.78	2	m
	Percentage of R&D expenses covered by gov. funding	26	0.22	0.89	2	m
	Governmental funding	28	0.10	0.75	1	c
Level of Expertise and training	Percentage of internal training capability	3	5.76	0.05	2	m
	Expertise of firm	6	2.55	0.10	1	c

Table 2: Modified Variates for Discriminant Analysis

Variates	Assigned Meaning	Standardised variables	Coefficient	Loading	Maximum Cronbach's alpha
V1	Innovation history	a. No. of new products developed in the last three years	0.80	0.8	NA
V2	Searching /Identifying capability	a. Technology or equipment for improvement of products b. No. of technologies or equipment as above c. No. of EU countries as potential suppliers of above d. No. of non-EU countries as potential suppliers of above	-0.45	-0.4	0.75
V3	Preparation for the future	e. Obstacles for acquisition of above f. favouritism perceived to be shown to LEE firm g. perception that alliance would be treated as a local firm by LEE government	0.19	0.3	0.85
V4	Magnitude of R&D resources	h. R&D expenditure 1996 i. Average R&D expenditure 1994-1996 j. Estimate of average R&D expenditure for next 3 years	----	----	0.97
V5	Technological capability	k. Maximum duration among projects of New products l. Holder of patents m. No. of patents n. Level of Firm's Expertise	-----	-----	0.70
V6	Innovation drive	o. No. of line of products developed by the firm p. No. of EU countries supplying product lines q. No. of non-EU countries supplying product lines	-----	-----	0.72

Hit ratio	77.5%
Function significance	0.001

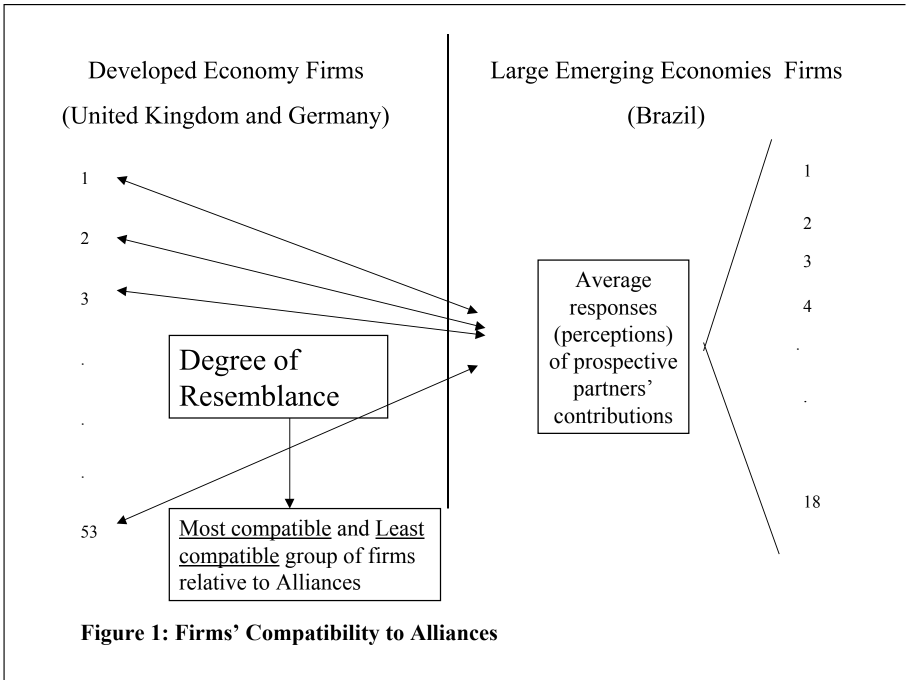

Figure 1: Firms' Compatibility to Alliances