International comparison of R&D investment by European, US and Japanese companies

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Abstract: Looking across the rapidly developing world, it is even more crucial for companies to benchmark their R&D investment against best international practice in their sector and to understand the ways in which their R&D investment will affect future business performance. The globalisation of technology requires a global analysis involving companies all over the world. In this study, top R&D European, US and Japanese companies are analysed and compared using R&D investment scoreboard reports. The main objective consists of extracting clusters of companies with similar R&D policies and comparing the obtained clusters with the major developed economic areas. Results will characterise companies in accordance with different R&D profiles, highlighting some asymmetries in the three major economic areas analysed.

Keywords: clustering; factor analysis; R&D investment; R&D policy; strategic groups; technology policy.

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1 Introduction

The concept of strategic groups has become an important, intermediate unit of analysis (between firm and industry) in developing theories of competition for the field of strategic management. The commonly accepted definition of a strategic group, according to Porter (1980, p.129), states that 'a strategic group is a group of firms in an industry following the same or a similar strategy along the strategic dimensions'. McGee and Thomas (1986) and Thomas and Venkatraman (1988) provide a thorough review of both the conceptual framework and current research work in this area, while Harrigan (1985) proposes the application of clustering procedures for strategic group analysis using the 'Mobility Barriers Paradigm' (1985, p.56). Further, according to both Harrigan (1985) and McGee and Thomas (1986), it is important not only to identify the presence of inter-group mobility barriers but also to examine how and to what extent these barriers influence competitive activity. As McGee and Thomas state (1986, p.153) 'Mobility barriers thus reflect the decisions of firms and are a way of defining the set of key strategies available to a firm'. Sudharshan et al. (1991) presented a procedure for identifying those key variables that act as mobility barriers in an industry.

One of the most important mobility barriers in an industry refers to research and development policies. Two sets of studies regarding R&D policies can be found in the literature: the first analyses the valuation effects of R&D expenditures by measuring and explaining market price response to R&D increase announcements (Chan et al., 2001), while the second explores the determinants of corporate R&D expenditures (Greeve, 2003). Some other studies have been devoted to comparing firms strongly involved in R&D activities (Martínez-Torres, 2006). Financial policies of R&D intensive firms from the US, Japan, the UK and some other European countries have been analysed by Bah and Dumontier (2001), concluding that they exhibit homogeneous financial policies in spite of their different institutional structures. The impact of globalisation and internationalisation is another topic of interest. As part of the process of globalisation, companies place more emphasis on the global management of technology. As a result, technology and product development processes are increasingly subject to internationalisation (Chiesa, 1996).

Several strategic grouping studies (e.g. Cool, 1985; Cool and Schendel, 1987; Dess and Davis, 1984; Fiegenbaum, 1987; Fiegenbaum and Thomas, 1990) have used cluster analysis to form strategic groups. Typically, cluster analysis leads to the development of strategic groups by grouping the companies in an industry based on their 'scores' on a set of important strategic variables representing key competitive resources typically chosen by the researcher on the basis of industry studies, expert opinion and judgement. In our paper, we have developed a factor analysis to extract the different strategic groups in top R&D investment companies from Europe, the US and Japan and to identify the kind of firms included in each group. Next, we have compared the results from these economic areas.

2 Context of study

The strategic and contingent perspectives state that technology intensive companies should use different approaches from traditional organisations. Technology intensive companies have been found to have several common characteristics that differentiate them from traditional enterprises, namely:

- a product that is highly advanced technologically
- greater priority placed on R&D
- frequent innovations
- high geographic concentration (e.g. Boston, Nice, Toulouse, Sun Valley)
- a high mortality rate
- a relatively high percentage of scientists and engineers in the workforce
- a high level of intellectual work
- an abnormally high turnover rate among technical personnel (Campbell and Guttel, 2005; Cardi and Dobbins, 1995; Gomez-Mejia et al., 1990a,b; Milkovich et al., 1991; Rogers, 2001). Tremblay and Chênevert (2004) hypothesised that technology intensive firms must adapt their strategies to their specific environment to reach their objectives.

As outlined above, strategic groups are made up of all those firms following the same or a similar strategy along strategic dimensions. We are going to analyse top R&D investment companies in the three major economic areas of the world, Europe, the US and Japan, in order to identify strategic groups. We hypothesise that we can identify similar patterns of behaviour in these different economic areas as a consequence of globalisation. Ten variables considered in previous studies have been selected to identify the different strategic groups (Schoenecker and Swanson, 2002). Six of them (V1, V2, V4, V7, V9 and V10) show the absolute data of companies not only related to R&D, but to some other features of companies, such as net sales, employees, operating profit, market capitalisation and capital expenditures. Two of them (V6 and V8) are ratios related to the R&D effort measured over net sales and number of employees. Finally, the last two variables (V3 and V5) are related to the evolution of the companies in term of net sales and number of employees. These variables are:

- V1: R&D investment
- V2: net sales
- V3: net sales change 04/03
- V4: employees 2004
- V5: employees change 04/03
- V6: R&D/net sales ratio
- V7: operating profit 2004 (% of net sales)
- V8: R&D/employees
- V9: market capitalisation 2004
- V10: capital expenditures 2004 (% of net sales).

The selection of these depended on the availability of data, their homogeneity and the quality and reliability of the information sources. In this sense, it was important to note that the quality of the output depended on that of the input.

3 Methodology for analysis

The required information was provided by *The 2005 EU industrial R&D investment Scoreboard* database (European Commission, 2005). All the firms with available information on all the selected variables were included in the sample. Table 1 presents the number and the percentage of included firms in each economic area considered in the analysis.

Table 1 Top industrial R&D investment companies from Europe, the US and Japan

	Europe		*USA*		*Japan*	
Industry	*Number*	*%*	*Number*	*%*	*Number*	*%*
Aerospace and defence	19	2.71	9	2.26	0	0.00
Automobiles and parts	37	5.29	15	3.77	23	11.62
Banks	3	0.43	0	0.00	0	0.00
Beverages	3	0.43	0	0.00	2	1.01
Chemicals	38	5.43	22	5.53	35	17.68
Construction and building	18	2.57	0	0.00	12	6.06
Diversified industrials	10	1.43	8	2.01	3	1.52
Electricity	10	1.43	0	0.00	7	3.54
Electronic and electrical	50	7.14	18	4.52	28	14.14
Engineering and machinery	81	11.57	17	4.27	15	7.58
Food and drug retailers	0	0.00	2	0.50	0	0.00
Food producers	24	3.43	3	0.75	4	2.02
Forestry and paper	7	1.00	3	0.75	2	1.01
General retailers	7	1.00	3	0.75	0	0.00
Health	23	3.29	20	5.03	1	0.51
Household goods and textiles	25	3.57	8	2.01	5	2.53
Insurance	1	0.14	0	0.00	0	0.00
IT hardware	49	7.00	112	28.14	18	9.09
Leisure and hotels	3	0.43	1	0.25	1	0.51
Life assurance	1	0.14	0	0.00	0	0.00
Media and entertainment	13	1.86	4	1.01	5	2.53
Mining	6	0.86	0	0.00	0	0.00
Oil and gas	13	1.86	10	2.51	1	0.51
Other financials	6	0.86	0	0.00	0	0.00
Personal care and household	8	1.14	8	2.01	2	1.01
Pharma and biotech	94	13.43	63	15.83	20	10.10
Software and computer services	83	11.86	60	15.08	4	2.02
Steel and other metals	12	1.71	1	0.25	5	2.53
Support services	26	3.71	7	1.76	0	0.00
Telecommunication services	16	2.29	1	0.25	2	1.01
Tobacco	2	0.29	2	0.50	1	0.51
Transport	4	0.57	0	0.00	2	1.01
Utilities – other	8	1.14	0	0.00	2	1.01
TOTAL	700	100.00	398	100.00	198	100.00%

Source: European Commission, 2005.

The sample comprises companies of 33 global sectors from the thirty-five sectors of the FTSE Global Classification System. The aim of the performed analysis consists of determining a small set of underlying dimensions able to summarise the information contained in the set of selected variables using factor analysis.

3.1 Factor analysis

Factor analysis is a way to fit a model to multivariate data, estimating their interdependence. It addresses the problem of analysing the structure of interrelationships among a number of variables by defining a set of common underlying dimensions, the factors (Hair et al., 1995), which are not directly observable, segmenting a sample into relatively homogeneous segments (Aguila-Obra and Padilla-Meléndez, 2006; Rencher, 2002). Since each factor may affect several variables in common, they are known as 'common factors'. Each variable is assumed to be dependent on a linear combination of the common factors and the coefficients are known as loadings. Mathematically, the factor analysis model expresses each descriptor as a linear combination of underlying common factors $f_1, f_2, \dots, f_m$, with an accompanying error term to account for that part of the variable that is unique (not in common with the other variables). For $y_1, y_2, \dots, y_p$ in any observation vector y, the model is as follows:

$$\begin{aligned} y_1-\mu_1 &= \lambda_{11}f_1+\lambda_{12}f_2+\dots+\lambda_{1m}f_m+\varepsilon_1 \\ y_2-\mu_2 &= \lambda_{21}f_1+\lambda_{22}f_2+\dots+\lambda_{2m}f_m+\varepsilon_2 \\ &\dots \\ y_p-\mu_p &= \lambda_{p1}f_1+\lambda_{p2}f_2+\dots+\lambda_{pm}f_m+\varepsilon_p \end{aligned} \tag{1}$$

Equation (1) can be written in matrix notation as in Equation (2), where Λ is the factor loadings matrix.

$$y-\mu=\Lambda f+\varepsilon \tag{2}$$

Ideally, m should be substantially smaller than p, otherwise we have not achieved a parsimonious description of the variables as functions of a few underlying factors. The coefficients λ_{ij} are called loadings and serve as weights, showing how each y_i individually depends on the underlying factors. With appropriate assumptions, λ_{ij} indicates the importance of the j^{th} factor f_j to the i^{th} variable y_i and can be used in interpretation of f_j. For instance, f_2 could be interpreted by examining its coefficients, $\lambda_{12}, \lambda_{22}, \dots, \lambda_{p2}$. The larger loadings relate f_2 to the corresponding *y*s. From these *y*s, a meaning or description of f_2 could be inferred. It is expected the loadings will partition the variables into groups corresponding to factors.

Factor analysis can be used for either exploratory or confirmatory purposes: exploratory analyses do not set any *a priori* constraints on the estimation of factors or the number of factors to be extracted while confirmatory analyses do. In our case, we have developed an exploratory analysis as we did not know the number of underlying dimensions.

Our analysis involved several decision-makings. First, we had to decide the method for extracting the factors. Second, the number of factors to be extracted has to be determined, evaluating how well they fit the original data. Finally, the extracted factors should be named in order to make easier their interpretation.

There are several extraction methods (Jolliffe, 1986; Spicer, 2005): principal components and principal axis factoring (or principal factor analysis) are among the most widely used. According to Hair et al. (1995), the former is used when the objective is to summarise most of the original information in a minimum number of factors, whereas the latter is used to identify the underlying dimensions reflecting what the variables share in common. In most applications, both methods arrive at essentially identical results. Since our objective was to obtain a small set of patterns of behaviour in top R&D investment companies, principal components seemed to be the appropriate method.

As we wanted to reduce the complexity of our problem, we had to decide on the number of factors to be extracted. There are several criteria for doing this, the most extensive being the eigenvalue and percentage of variance criteria. For the eigenvalue criterion, all of them should be at least higher than 1 to be retained. This guarantees that any factors accounts for at least the variance of a single variable. Meanwhile, the percentage of variance criterion considers all factors accounting for at least 60% (typically but sometimes 80%) of the variance of the original variables (Vicente Cuervo et al., 2006). In our case both criteria suggested retaining three factors, which explained more than 70% of the total variance of the original variables.

Once the number of factors has been determined, the next step is to interpret them according to the factor loadings matrix. The estimated loadings from an unrotated factor analysis fit can usually have a complicated structure. Fortunately, an interesting property of loadings is that they can be multiplied by an orthogonal matrix preserving the essential properties of the original loadings. Let T be an arbitrary orthogonal matrix, $TT'=I$. Inserting TT' into the basic Equation (2):

$$y-\mu=\Lambda TT' f+\varepsilon \tag{3}$$

Associating T with Λ and T' with f, the model becomes:

$$y-\mu=\Lambda^{*} f^{*}+\varepsilon \qquad \text{with } \Lambda^{*}=\Lambda T \text{ and } f^{*}=T' f \tag{4}$$

It can be demonstrated that the new loadings $\Lambda^{*}=\Lambda T$ reproduce the covariance matrix (Rencher, 2002). This property is frequently used to facilitate the interpretation of factors. If we can achieve a rotation in which every point is close to an axis, then each variable loads highly on the factor corresponding to the axis and has small loadings on the remaining factors. In this case, there is no ambiguity. The rotated factor analysis fit ensures that factors represent unidimensional constructs. We applied the varimax rotation, introduced by Kaiser in 1958.

4 Results

The main applications of factor analysis techniques are to classify and to reduce the number of variables, structuring the relationships between them. Factor analysis attempts to identify underlying variables or factors, which can explain the pattern of correlations within a set of observed variables. In our analysis, each factor represents a distinguished pattern of behaviour of R&D intensive companies. The analysis has been performed for each of the considered economic areas, in order to compare the obtained results.

Factor analysis has been performed using the principal component method. The eigenvalues of the sample covariance matrix are shown in Table 2. In factor analysis, it is usual to consider a number of factors equal to the number of eigenvalues higher than 1. We have also considered that the number of factors is able to explain 70% of our variable. In our results, up to three factors satisfy this condition. Table 2 also illustrates the percentage of variance explained by each factor and the cumulative variance. The considered three factors account for more than 70% of the total sample variance and, therefore, represent the ten starting variables sufficiently accurately.

Table 2 Total variance explained

	Europe			*USA*			*Japan*		
	Initial eigenvalues			*Initial eigenvalues*			*Initial eigenvalues*		
Factors	*Total*	*% of variance*	*Cumulative %*	*Total*	*% of variance*	*Cumulative %*	*Total*	*% of variance*	*Cumulative %*
1	3.116	31.158	31.158	3.254	32.536	32.536	3.516	35.155	35.155
2	2.797	27.967	59.125	2.770	27.701	60.237	1.938	19.384	54.539
3	1.313	13.133	72.258	1.199	11.989	72.226	1.677	16.767	71.307
4	0.855	8.551	80.809	0.871	8.714	80.940	1.128	11.279	82.586
5	0.725	7.255	88.064	0.778	7.777	88.717	0.546	5.463	88.049
6	0.589	5.895	93.958	0.499	4.986	93.703	0.527	5.268	93.317
7	0.325	3.250	97.208	0.396	3.964	97.667	0.324	3.240	96.557
8	0.154	1.544	98.752	0.158	1.577	99.245	0.218	2.182	98.738
9	0.123	1.230	99.982	0.065	0.653	99.897	0.080	0.796	99.534
10	0.002	0.018	100.000	0.010	0.103	100.000	0.047	0.466	100.000

Using the associated eigenvectors, factor loadings can be estimated. Sometimes, it is difficult to perform the right interpretation of factors using the estimated loadings. Fortunately, factor loading can be rotated through the multiplication by an orthogonal matrix. The rotated loadings preserve the essential properties of the original loadings.

The varimax method is an orthogonal rotation method that minimises the number of variables that have high loadings on each factor. This method simplifies the interpretation of the factors. Table 3 reports the rotated factor loadings with varimax rotation for each of the economic areas analysed.

To extract the meaning of each factor, we move horizontally through Table 3, from left to right, across the three estimated loadings of each variable, identifying the highest loading and the corresponding factor. To assess significance of factor loadings, a threshold value of 0.6 was considered (Rencher, 2002).

The resulting aggregation of variables leads to the following latent factors for each economic area, included in Table 4.

Table 3 Rotated component matrix

	Europe			USA			Japan		
	Component			Component			Component		
Variable	*1*	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*3*
VAR1	0.006	0.752	−0.007	−4.41E-005	0.827	−0.009	0.111	0.944	−0.024
VAR2	−0.028	0.918	−0.030	−0.036	0.879	−0.073	−0.103	0.969	−0.030
VAR3	−0.030	−0.013	0.828	−0.017	0.032	0.767	−0.024	−0.033	0.756
VAR4	−0.046	0.837	−0.054	−0.068	0.854	−0.167	−0.108	0.904	−0.027
VAR5	0.038	−0.050	0.775	−0.083	−0.099	0.627	−0.170	−0.005	0.769
VAR6	0.977	−0.006	−0.062	0.991	−0.029	−0.010	0.883	−0.042	−0.141
VAR7	−0.965	0.000	0.086	−0.985	0.037	0.002	0.458	0.032	0.633
VAR8	0.567	−0.080	0.176	0.485	−0.140	0.470	0.929	−0.004	−0.001
VAR9	−0.015	0.830	−0.021	−0.024	0.830	0.023	0.076	0.883	0.132
VAR10	0.933	0.024	−0.042	0.928	0.006	−0.118	−0.144	0.271	0.286

Table 4 Latent factors

	Europe	*USA*	*Japan*
(Factor 1) Knowledge intensive companies which need a high effort in R&D	V6: R&D/net sales ratio V7: operating profit 2004 (% of net sales) (negative) V8: R&D/employees V10: capital expenditures 2004 (% of net sales)	V6: R&D/net sales ratio V7: operating profit 2004 (% of net sales) (negative) V8: R&D/employees V10: capital expenditures 2004 (% of net sales)	V6: R&D/net sales ratio V8: R&D/employees
(Factor 2) Large companies which consider R&D a strategic value for competition	V1: R&D investment V2: net sales V4: employees 2004 V9: market capitalisation 2004	V1: R&D investment V2: net sales V4: employees 2004 V9: market capitalisation 2004	V1: R&D investment V2: net sales V4: employees 2004 V9: market capitalisation 2004
(Factor 3) Quickly growing companies	V3: net sales change 04/03 V5: employees change 04/03	V3: net sales change 04/03 V5: employees change 04/03	V3: net sales change 04/03 V5: employees change 04/03 V7: operating profit 2004 (% of net sales)

The first factor describes knowledge intensive companies in which R&D spending is the primary way in which firms differentiate themselves. Basically, this factor exhibits a high value of V6 and V7 loading, corresponding to the R&D effort. In Europe and the US, as a difference from Japan, the factor shows a low operating profit margin and high capital expenditures. The low operating profit means a low value compared with companies belonging to the other two factors. The association of R&D and capital expenditures has been tested by Amir et al. (2007) in R&D intensive industries.

The second factor is explained by exactly the same variables in the three studied economic areas. This factor comprises large companies where R&D is one of the strategic values for competition. The high value of net sales, employees and market capitalisation confirm that, although R&D investment is higher than in the rest of the factors, the ratios of R&D effort (R&D intensity and R&D per employee) do not reach the values of companies grouped in factor 1.

Finally, the third factor is explained by variables related to big changes during the last year, such as net sales change and employees change. As a result, the third group has been defined as quickly growing R&D companies. In the case of Japan, variable V7 (operating profit) is also included in this factor.

The mean values of the variables per strategic group and economic area are shown in Table 5. To assess the significance of these results, the null hypothesis of equal population means should be rejected. An analysis of variance (ANOVA) has been performed for this purpose and the obtained results allow us to reject the null hypotheses in all the cases with a significance value below 0.05.

Table 5 Mean values of selected variables per strategic group and economic area

	Europe			*USA*			*Japan*		
	Factor 1	*Factor 2*	*Factor 3*	*Factor 1*	*Factor 2*	*Factor 3*	*Factor 1*	*Factor 2*	*Factor 3*
Var 01	24.36	756.3	33.90	77.65	1115.51	143.37	208.37	1318.04	132.75
Var 02	432.18	26461.8	1191.18	70.87	28714.83	1240.04	2040.07	31101.20	4556.96
Var 03	−11.40	5.6	47.19	11.36	12.09	61.81	1.80	2.11	12.33
Var 04	1459.91	93355.3	6068.32	565.33	85250.95	4857.60	6086.41	102514.05	17389.07
Var 05	−4.36	−1.4	28.09	−1.72	−1.79	25.17	−3.35	0.21	10.45
Var 06	245.39	4.0	14.95	615.21	6.02	33.41	11.15	3.91	4.09
Var 07	−2087.92	9.3	−0.27	−851.76	12.18	−13.79	9.69	6.00	10.40
Var 08	126.66	9.61	21.71	156.89	17.52	65.14	37.69	11.64	10.55
Var 09	1119.24	28322.32	1420.61	691.79	44108.58	5759.46	3758.83	19395.63	4551.28
Var 10	28.31	6.35	6.48	147.93	4.27	7.67	3.67	6.47	6.23

Looking carefully at Table 5, it can be observed that companies from the US included in factor 1 are characterised because their R&D/net sales is three times higher than in Europe and they also have the highest value of capital expenditures. However, companies from Europe, also included in this factor, show very negative operating profit. This has been defined as gross profit minus marketing, engineering and administration costs and

R&D costs, (European Commission, 2005). The reason for this negative result is due to the high effort in R&D they require to reach a differentiation respect to competing firms. Finally, while European and US companies have a similar number of R&D employees, in Japan this value drops to a third.

Looking at factor 2, European companies have less investment in R&D, although their net sales are similar to those from the other economic areas. The Japanese companies are the ones with the highest numbers of employees while the European and US companies exhibit the highest operating profit.

Finally, in accordance with the last factor, Japanese companies are those with most net sales and employees changes, with their operating profit also being the highest.

The obtained results clearly illustrate the same patterns of R&D companies for Europe and the US but with some differences in the case of Japan, particularly in factors 1 and 3. The profile of quickly growing companies in Europe and the US is based on employees and net sales growth, while in the case of Japan these kind of companies also grow in operating profit.

In addition to the factor loading, factor scores can also be obtained from factor analysis. Using factor scores, each of the observations (companies) can be assigned to one or none of the latent factors. The assignation has been performed using the maximum factor score, provided that this maximum value is higher than 0.1 (Rencher, 2002). Table 6 shows the kind of companies and the number of them classified in the three latent factors obtained for each economic area.

According to Table 6, it can be observed that the sectors of activity of the included companies vary among the three economic areas considered. Companies grouped as 'knowledge intensive companies which need a high effort in R&D' are, in Europe, mostly oil and gas companies (e.g. BG), mining companies (e.g. Anglo American or Rio Tinto), some chemicals companies (e.g. Bayer) and automobiles and parts companies (e.g. Daimler Chrysler). In the US, this strategic group would only be made up by pharma and biotech companies (e.g. Human Genome Sciences). Finally, Japan would include most of its chemicals companies (such as Mitsubishi Chemical) and some of its pharma and biotech companies (e.g. Fujisawa Pharmaceutical).

Companies clustered in the second factor 'large companies which consider R&D a strategic value for competition' are, in Europe, most of its pharma and biotech companies, although some IT hardware companies (e.g. ARM) have also been included. In the US, most of the oil and gas companies are included here, although we could also find some aerospace and defence (e.g. Boeing) and automobiles and parts companies (e.g. Ford Motor). In Japan, the companies included in this group are mainly, automobiles and parts (e.g. Toyota Motor) and electronic and electrical companies (e.g. Sony).

Finally, in the last strategic group, 'Quickly growing companies', we can mainly identify electronic and electrical (e.g. Gemplus International) and software and computer services companies (e.g. Intec Telecom Systems) in Europe. The latter can also be found in the US (e.g. Google), although IT hardware (e.g. Quantum) and pharma and biotech companies (e.g. Cephalon) can also be included in this group. In Japan, we can identify companies belonging to sectors of activity which have been included in the previous group, such as automobiles and parts (e.g. Toyota Industries), chemicals (e.g. Kaneka) and electronic and electrical (e.g. TDK).

Table 6 Companies included in each strategic group

	Europe		*USA*		*Japan*	
Knowledge intensive companies which need a high effort in R&D	Aerospace and defence	6	IT hardware	6	Automobiles and parts	1
	Automobiles and parts	11	Pharma and biotech	17	Chemicals	9
	Banks	1	Software and computer services	1	Electronic and electrical	2
	Beverages	1			Engineering and machinery	1
	Chemicals	8			Household goods and textiles	1
	Construction and building	3			IT hardware	3
	Diversified industrials	2			Pharma and biotech	19
	Electricity	3			Software and computer services	3
	Electronic and electrical	6				
	Engineering and machinery	6				
	Food producers	3				
	Forestry and paper	2				
	General retailers	4				
	Health	1				
	Household goods and textiles	2				
	IT hardware	4				
	Leisure and hotels	1				
	Media and entertainment	2				
	Mining	3				
	Oil and gas	7				
	Personal care and household	3				
	Pharma and biotech	8				
	Software and computer services	1				
	Steel and other metals	2				
	Support services	3				
	Telecommunication services	8				
	Tobacco	1				
	Transport	1				
	Utilities – other	5				

Table 6 Companies included in each strategic group (continued)

	Europe		*USA*		*Japan*	
Large companies which consider R&D a strategic value for competition	Automobiles and parts	1	Aerospace and defence	6	Automobiles and parts	8
	Electricity	3	Automobiles and parts	7	Chemicals	1
	Electronic and Electrical	1	Chemicals	2	Construction and building	2
	Forestry and paper	1	Diversified industrials	3	Electricity	3
	Health	1	Electronic and electrical	3	Electronic and electrical	8
	IT hardware	10	Engineering and machinery	4	Engineering and machinery	1
	Oil and gas	2	Food and drug retailers	2	IT hardware	5
	Pharma and biotech	41	Forestry and paper	3	Media and entertainment	1
	Software and computer services	4	General retailers	1	Steel and other metals	1
	Support services	2	Health	3	Telecommunication services	2
	Telecommunication services	1	Household goods and textiles	1	Tobacco	1
	Utilities – other	2	IT hardware	11	Transport	1
			Media and entertainment	2		
			Oil and gas	5		
			Personal care and household	4		
			Pharma and biotech	8		
			Software and computer services	3		
			Steel and other metals	1		
			Support services	1		
			Telecommunication services	1		
			Tobacco	1		

Table 6 Companies included in each strategic group (continued)

	Europe		*USA*		*Japan*	
Quickly growing companies	Aerospace and defence	3	Chemicals	1	Automobiles and parts	5
	Automobiles and parts	3	Electronic and electrical	1	Chemicals	4
	Chemicals	1	Engineering and machinery	3	Electronic and electrical	5
	Construction and building	1	General retailers	2	Engineering and machinery	2
	Diversified industrials	1	Health	2	IT hardware	5
	Electricity	1	IT hardware	37	Media and entertainment	1
	Electronic and Electrical	6	Pharma and biotech	16	Personal care and household	1
	Engineering and machinery	3	Software and computer services	13		
	Food producers	3				
	Forestry and paper	1				
	General retailers	1				
	Health	2				
	Household goods and textiles	1				
	IT hardware	6				
	Leisure and hotels	1				
	Media and entertainment	1				
	Oil and gas	1				
	Pharma and biotech	1				
	Software and computer services	6				
	Steel and other metals	2				
	Telecommunication services	1				

The similarity of the identified groups in the three major economies of the world suggests the existence of a real global competition of R&D intensive companies and, therefore, the existence of strategic groups with technological policies clearly differentiated. The main consequence is that processes of technological change have become even more complex and challenging, with growing R&D costs and shorter product life cycles. Driven by convergence, globalisation and new technologies, changes are coming faster and disruptions to legacy business modes and products are cutting deeper. As the three economic areas considered in this study aspire to maintain or to reach a leadership position in research, development and innovation, they should be able to adapt to a changing environment. From our study it can be concluded that R&D is not only concentrated in large companies such as the ones clustered in factor 2 but also in knowledge intensive and emergent quickly growing companies and it is more focussed on near-term research. Longer-term research funding, in general, has been declined as part of an overall re-engineering of R&D, especially in sectors such as electrical machinery, electronic equipment and components, aerospace and, to a certain extent, industrial chemicals. The major part of investment in basic research for technology creation is supported by national governments. In order to justify this substantial investment, it is necessary to get the research from the laboratory to the private company that will commercialise the technology. In this sense, the group of 'quickly growing companies' is called to fill the gap between the long and near term research.

5 Conclusions

The purpose of this paper has been the identification and comparison of different strategic groups in Top R&D investment companies from three economic areas: Europe, the US and Japan. Three kinds of strategic groups have been identified.

The first strategic group, 'Knowledge intensive companies which need a high effort in R&D', is mainly characterised because the importance of R&D in relation to its employees and its net sales is very high. In Europe and the US, the companies from this strategic group have high capital expenditures but their operating profit has a negative influence on them.

The second strategic group, 'Large companies which consider R&D a strategic value for competition', are characterised because its companies invest too much in employees and R&D, as they are considered to be something of value to compete. These companies get high net sales and have a high market capitalisation.

Finally, the last strategic group, 'Quickly growing companies', is mainly characterised because of the change in their net sales and in their employees. In Japan, the companies in this strategic group are the one with highest operating profit.

Although the strategic groups identified in Europe, the US and Japan are similar, the kind of companies included in them are different.

In Europe, oil and gas, mining, chemicals and automobiles and parts are the most outstanding companies from the first strategic group, pharma and biotech and IT hardware are the kind of companies we can find in the second strategic group and electronic and electrical and software and computer services are in the third group.

In the US, pharma and biotech companies are included in the first and the third strategic group while in the second group we can find oil and gas, aerospace and defence and automobiles and parts companies.

Finally, in Japan, chemicals companies are characterised because they are knowledge intensive companies which need a high effort in R&D, as pharma and biotech but they are also quickly growing companies. Automobiles and parts and electronic and electrical are companies which consider R&D a strategic value for competition and they are also quickly growing companies.

Some limitations of the research should be considered. First, our analysis refers to the top R&D investment companies in three economic areas at a given date. However, a proper appreciation would require an understanding of their time evolution. Second, our empirical application consists of just ten variables. Hence, some aspects of the investments may not be covered.

Finally, once the strategic groups have been identified, the barriers to mobility should be identified in order to prevent companies moving from one strategic group to another. In this sense, companies belonging to the quickly growing strategic group represent the main threat to companies belonging to the rest of strategic groups, as they are growing to overcome mobility barriers.

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