Paper Prepared for the 28th EIBA Conference,
December 8-10, 2002, Athens, Greece

Diversification Profiles of Multinational Corporations:

An Empirical Investigation of Geographical Diversification, Product Diversification and Technological Diversification

submitted by

Michael STEPHAN

Hohenheim University

Center for International Management and Innovation

Department of Business Administration

Schloss Osthof-Nord

D-70599 Stuttgart

+49-711-459-29 42 (Tel)

+49-711-459-34 46 (Fax)

stephanm@uni-hohenheim.de

- September 2002 -

Abstract

Building upon a firm-level empirical investigation we conduct a phenomenological analysis of corporate diversification patterns. We take up a more holistic, multilevel approach towards corporate diversification: In our investigation we capture both diversification at the output level, at the input level, and at the geographical market level. The empirical observations are based on a study of trends in corporate diversification in a fifteen years period ranging from 1983 to 1997. Our sample comprises 46 multinational corporations headquartered in the triad countries. Based on our three-dimensional view of diversification, we can derive different phenotypes of corporate diversification. Each phenotype is characterized by a distinctive corporate diversification pattern. From a dynamic perspective these phenotypes translate into paths of evolution of corporate diversification patterns. It can be shown, that there are several homogenous groups of sample companies with similar corporate diversification patterns and similar paths of evolution.

Keywords:

Product Diversification

Technological Diversification

Geographical Diversification

Evolutionary Economics

MNCs

Introduction

The world's largest multinational corporations are actively engaged in a multitude of businesses and usually manage a broad spectrum of technological resources. In contrary to international diversification and product diversification, the latter phenomenon - technological diversification - has attracted comparatively little attention in management research (Breschi, Lissoni, and Malerba, 1998). A few empirical studies have come to the conclusion that technological diversification had been on the rise in the 1970s and 80s (Fai, 1999; Granstrand and Oskarsson, 1994; Kodama, 1995; Oskarsson, 1993, Sjölander and Oskarsson, 1995). This increase has been observed at corporate level across all industries and across all triad countries. Various empirical investigations in international management research have revealed that most of the multinational corporations have further increased the geographical range of their business activities during that period of time. However, and most interestingly, at the same time numerous studies have revealed that product diversification has been declining during the same period of time (e.g. Markides, 1996). Common to most of these studies is that they take up a partial view on corporate diversification: They either focus on output diversification, i. e. product or business diversification, or they concentrate on input diversification, e. g. technological diversification, or they analyze international diversification, i. e. geographical diversification. A few studies in the domain of product diversification research have tried to take up at least a two-dimensional view of corporate diversification. Sambharya (1995) and Kim et al. (1993), for example, have analyzed the combined effect of international diversification and product diversification strategies on the performance of U.S.-based multinational corporations. However, beyond these product diversification-centered approaches there exists no detailed multilevel-analysis of the corporate diversification phenomenon.

This paper tries to overcome this deficiency and takes up a more holistic, multilevel approach. In our empirical investigation we will capture both diversification at the output level, at the input level and at the geographical level. Building upon a corporate-level empirical investigation we conduct a phenomenological analysis of corporate diversification patterns. The empirical observations are based on a study of trends in corporate diversification in a fifteen years period ranging from 1983 to 1997. The sample comprises 46 multinational corporations headquartered in the triad countries. Based on our three-dimensional view of diversification, we can derive different phenotypes of corporate diversification. Each phenotype is characterized by a distinctive corporate diversification pattern. From a dynamic perspective these phenotypes translate into paths of evolution of corporate diversification patterns. It can be shown, that there are homogenous groups of sample companies with similar corporate diversification patterns and similar paths of evolution. Furthermore, most of the diversification patterns change only gradually over time.

The paper is organized according to the following plan. The first section introduces our empirical data and discusses the methodology that we have employed in capturing corporate diversification. The next section presents the recent trends in product diversification, technological diversification, and geographical diversification. Building upon this three-dimensional empirical analysis we then derive phenotypes of corporate diversification patterns. We conclude the empirical part of the paper with an illustration of the individual paths in the evolution of the corporate diversification patterns. The final section elaborates implications of and extensions to this research.

Methodology – Sample Selection and Data Collection

To analyze corporate diversification patterns of firms we selected 46 multinational corporations from the international R&D Scoreboard ranking of the top 300 companies by R&D expenditures (random selection).[1] The sample companies are headquartered in the U.S. (15), Europe (12) and Japan (11). For each company we assembled an extensive data set covering statements about financial measures (revenues, R&D expenditures), technological resources (technology portfolio), product diversification (product portfolio) and international diversification (geographical market portfolio) for a time period of 15 years (1983-1997) on an annual basis. Data on product diversification and international diversification were assembled from the annual reports and other primary company sources. Product diversification is captured by the dispersion of the firms' product sales across 4-digit-ISIC codes. Correspondingly, international diversification is captured by the dispersion of the firms' sales across major regional (geographical) markets.[2] In contrast to product diversification and international diversification, a direct measure of technological resources or technological activities of firms is not available. The approach to grasp technological diversification is to view technology as consisting of a number of distinct 'technological areas' (for a similar approach see e. g. Jaffe, 1989). A multi-technology corporation will typically engage in R&D in a number of such areas. From this perspective, technological activities can be measured by two fundamental proxies: patents and R&D expenditures. While R&D

---

1 The term 'multi-technology corporation' was introduced to the technology management literature by Granstrand and Sjölander (1990). The R&D scoreboard is published annually by the UK Department of Trade and Industry (DTI).

expenditures are an input measure, patent filings are an indicator of the firm's innovative output (Gavetti, 1994). The paper uses patent data to characterize the technological position of firms and to measure technological diversification.

The method of measuring technological diversification in our investigation is based on the notion that patents are a more valid indicator to assess technological resources and activities of firms. According to Gavetti (1994) and Pavitt (1988) we can synthesize the major advantages of the use of patents as follows:

- Patent data are effective and valid measures of the technological activities of companies;
- Patent data also capture technological activities that are not rooted in the formal R&D organization;
- Patents offer detailed information on the relevant technological area, which is of particular relevance in order to assess the spectrum of technological activities of companies.

However, the author is well aware that patents are far from being a perfect proxy. The construct validity of the indicator is weakened by the fact that patents do not grasp technological activities that are not characterized by technical novelty (originality). The contents validity of patent data is impaired by the fact that the propensity to patent differs amongst technical fields, reflecting differences in the relative importance of patenting as a protection against imitation. In the absence of a more appropriate alternative, we believe that the granting of a patent reflects the judgment that the applicant has the competence to improve technology in a given field significantly.

To minimize the home country bias in comparing the technological activities of the sample companies headquartered across the U.S., Japan and Europe, we analyze the patent filings at the European Patent Office (see also Schmoch, 1999). To assess the diversity of the patent portfolios of the sample companies we have adopted a technology-oriented classification system which has been elaborated jointly by the German Fraunhofer Institute of Systems and Innovation Research (ISI), the French Patent Office (INIPI) and the Observatoire des Science and des Techniques (OST). The so called "OST/INPI/ISI"-technology classification is based on the International Patent Classification (IPC) and distinguishes between 30 different fields of technology and five higher-level technology areas (see figure 1). For each patent filing we collected information about the IPC class which was assigned by the patent examiners at the European Patent Office and then reassigned it to the corresponding OST/INPI/ISI-classification.

---

2 As alternative measures of international diversification one may use the global dispersion of firms' assets and international employment data. However, these alternative indicators generally suffer from the lack of availability of firm-level data. For a detailed discussion of the scope and limits of indicators to measure the degree of internationalisation see Stephan, Pfaffmann (2001).

--- Put Figure 1 about here ---

For each sample company we compiled the technology portfolios for the three five-years periods 1983-1987, 1988-1992 and 1993-1997. The aggregated observation of five-years periods served to eliminate cyclical fluctuations in the individual firms' patent filings. Although the EPO database covers information about patent filings dating back to 1978, our analysis starts in 1983. In fact, the sample of patents from 1978-1982 could be biased by the fact that only large European firms are likely to have used the European Patent Office since its very beginning. Figure 2 illustrates the profiles of the technology portfolios of the sample companies for the period 1993-1997 according to their 'core' technology fields. By employing a non-hierarchical cluster analysis we were able to identify eight homogenous groups of companies with similar technology profiles ("Telecom", "Computer/Electronics", "System Technology", "Automotive", "Engines/Pumps/Turbines", "Materials", "Chemicals", "Pharmaceuticals"). Each cluster is characterized by a specific set of core technologies that the member companies have focused on. Besides the eight clusters with homogenous technology profiles we have a residual of companies that do not fit into any of these groups. The nonconforming companies are grouped into the "hybrid" cluster.

--- Put Figure 2 about here ---

Analogue to the technology portfolio we compiled the geographical market portfolios and product portfolios for each company. To compile the geographical market portfolios we collected the firms' revenues in the major global regions. In our study, the major global regions correspond to relatively heterogonous geographical market areas based on their economic and political conditions. We differentiate between 6 geographical market areas. These are: North America, Latin America, Europe, Africa/Middle East, Asia/Pacific and the individual home country of each sample corporation. To compile the product portfolios we collected the firms' revenues in different ISIC classes (International Standard Industrial Classification) on a 4-digit level. Figure 3 illustrates the profiles of the product portfolios of the sample companies for the period 1993-1997 according to their top-selling businesses. Again, by employing a non-hierarchical cluster analysis we were able to identify homogenous clusters of companies. On the whole, we have identified ten industry clusters with more or less homogenous product profiles: "Chemicals", "Pharmaceuticals"; "Materials"; "Metal Products"; "Automotive"; "Engines/Machinery"; "Diversified Electrical Engineering", "Telecommunications"; "Consumer Electronics", and "IT/Computer". Surprisingly, the product clusters only partially correspond to the technology clusters. While some of the clusters find rough correspondents in the other dimension, with moderate differences in terms of composition, others do not have similar counterparts. Obviously there is a certain degree of decoupling. The phenomena of decoupling will be picked up again when we observe the latest trends in technological diversification and product diversification.

--- Put Figure 3 about here ---

Measures and Trends in Technological Diversification (1983-1997)

Technological diversification is captured with the single entropy measure. The single entropy measure grasps the degree of unrelated technological diversification. With 30 different technological fields (i=1...N; N ≤ 30), for each of the sample companies the degree of unrelated technological diversification (*DT*) is computed as follows (let *Ti* be the share of the *i*th technological field in the total patent filings of the firm):

$$DT = \sum_{i=1}^{N} T_i \ln(1/T_i) \, .$$

This measure takes into consideration two elements of technological diversification: the number of technological fields in which a firm operates and the relative importance of each of these fields compared to the total number of patent filings.

Figure 4 provides an overview of the trends in technological diversification differentiated by industries of the sample companies. In the 1980s, the sample companies have (slightly) increased their degree of (unrelated) technological diversification. However, at the beginning of the 1990s, this trend has come to a halt. In the 1990s the sample companies have begun to refocus their technology portfolio. This observation is new: In contrast to the findings of prior empirical studies of previous periods, there has been a decrease in technological diversification by more than three per cent. Figure 4 also reveals that there exist considerable differences between the sample companies from different industries. Companies from the telecom cluster have dramatically refocused their technology portfolio in the 1983-1997 period. Like the companies from the pharmaceutical cluster, telecom firms manage a technology portfolio that is considerably less diversified than the sample average. In contrast, companies from the automotive, diversified electric engineering and chemicals/materials clusters are engaged in a spectrum of technological activities that is high above the average.[3]

---

3 There also exist regional differences in the sample. Firms from the U.S. are less diversified than firms from Japan and Germany. On the average, U.S. firms have begun to refocus their technology portfolio already in the 1980s, whereas firms from Japan have still been broadening their activities during the 1990s.

--- Put Figure 4 about here ---

Measures and Trends in Product Diversification (1983-1997)

Analogue to the measure of technological diversification, the degree of product diversification is captured with the single entropy measure. This International Standard Industrial Classification (ISIC) based index grasps the degree of unrelated product diversification. We differentiate between 68 industry segments that are based on 4-digit ISICs ($k=1...S$; $S \leq 68$). For each of the sample companies the degree of unrelated product diversification (*DP*) is computed as follows (let P_k be the share of the *k*th industry segment in the total sales of the firm):

$$DP = \sum_{k=1}^{68} P_k \ln\left(\frac{1}{P_k}\right)$$

Again, the entropy measure takes into consideration two elements of diversification: the number of segments in which the firm operates and the relative importance of each of these segments in the total sales of the firm. Figure 5 visualizes the trends in product diversification differentiated by industry of the sample companies.

--- Put Figure 5 about here ---

At first sight, differences between the overall trends in product diversification and technological diversification become evident: the sample companies have constantly reduced their degree of product diversification. This observation corresponds to the findings of previous empirical studies: In the 1980s and 1990s, companies have been refocusing their product portfolios. Differences in the trends by industries are even more striking. In the automotive industry cluster for example, the companies have constantly expanded their technology portfolio in the 1980s and 90s. Contrary to this trend, the automotive sample companies have refocused their product portfolios in the 1990s. Furthermore, concurrent divergences have been ascertained in the chemicals/materials cluster, whereas reverse divergences exist in the consumer electronic industry cluster. Consumer electronic firms have increased the span of their products/businesses and at the same time decreased the spectrum of their technological activities. The divergences confirm the suspicion made earlier in the paper: there exists a considerable degree of decoupling between technological diversification and product diversification, at least in some industries.

Measures and Trends in International Market Diversification (1983-1997)

Analogue to the measures of technological diversification and product diversification, the degree of international diversification is captured with the single entropy measure. The entropy measure reflects the extent of the dispersion of the firms' sales across the major global markets. As mentioned above, we differentiate between 6 geographical market areas (m=1...R; R ≤ 6). For each of the sample companies the degree of international market diversification (*DG*) is computed as follows (let G*m* be the share of the *m*th geographical market area in the total sales of the firm):

$$DG = \sum_{m=1}^{6} G_m \ln\left(\frac{1}{G_m}\right)$$

Again, the entropy measure takes into consideration two elements of diversification: the number of the geographical markets in which the firm operates and the relative importance of each of these markets in the total sales of the firm. Nearly all of the sample companies had already globalized their businesses to a considerable degree at the beginning of the 1980s. Nevertheless, most of the companies have further increased their degree of international diversification during the period of investigation. Figure 6 visualizes the trends in international diversification differentiated by home country of the sample companies.

--- Put Figure 6 about here ---

Figure 6 shows that companies have continuously increased their degree of geographical diversification in the 1980s and 1990s, irrespective of their home country. However, figure 6 also reveals that there exist considerable differences in the degree of internationalization between the different country clusters. On the average, companies based in Germany lead the pack in terms of geographical diversification, although the degree of internationalization has stagnated in the German cluster between the first and second period as a result of strong domestic growth caused by the reunification. In contrary, companies from Japan rank far below the sample average. Considerable differences also exist between the industry clusters in the sample. On the average, multinational corporations from the pharmaceutical, telecom and machinery clusters have spread their sales more equally across global markets than other companies –automotive companies, in particular, have focused their sales on a limited number of core markets. Figure 7 visualizes the trends in international diversification differentiated by the industry clusters of the sample companies.

--- Put Figure 7 about here ---

To sum up, this threefold, isolated analysis of recent trends in corporate diversification has shown a considerable degree of homogeneity within the company cluster. At the same time the analysis has also revealed considerable differences between the different diversification levels. Obviously, these dimensions are (partially) decoupled from each other. In the following section we will analyze the degree of decoupling more thoroughly, in order to shed some light on the relationship between the diversification levels.

Patterns and Phenotypes of Corporate Diversification

One way to reveal the extent of decoupling in the sample is to merge the diversification levels in a single frame of analysis. However, product diversification, technological diversification and geographical diversification cannot be compared directly on the basis of the entropy values. Although we have employed identical measures to calculate the degree of input, output and regional diversification, comparability is hampered by differences in scaling (different maximum values). This in turn is caused by differences in the underlying classification indices (ISIC vs. OST/INPI/ISI vs. geographical market areas). To bypass the ‘apples and oranges’ problem, we simply relate both the degree of product diversification, the degree of technological diversification and the degree of international diversification of each company to the sample average. With relational data we are able to compare technological diversification, product diversification and international diversification within the same frame of analysis and without biases. For the present we use a two-dimensional view on corporate diversification to keep the analysis clear. We start with the firm-level comparison of relational technological diversification data and relational product diversification data. Figure 8 visualizes the corporate input and output diversification patterns at the end of the investigation period (1993-1997).

--- Put Figure 8 about here ---

The comparison of technological diversification and product diversification enables us to derive a typology of four different phenotypes of input-/output-diversification (IO). Each IO-phenotype is characterized by a specific pattern of corporate diversification.

- *IO-Phenotype 1* is characterized by a focused product portfolio and by a diversified technology portfolio: this pattern is symptomatic for companies with complex products, for instance in the automotive industry. Companies like GM or DaimlerChrysler (Daimler Benz) have (re)focused their product portfolios and have outsourced significant proportions of their production to external suppliers, while they simultaneously maintain a diversified technology base in-house.

- *IO-Phenotype 2* exhibits both a broadly diversified product and a broadly diversified technology portfolio – the link between the technology and product base is complex: Diversified electronic and machinery companies like GE, Siemens, Hitachi, UTC, ABB or Mitsubishi Electric are engaged in a large number of product fields, with varying degrees of technological relatedness. At the same time, the companies use their broad spectrum of technologies in a variety of different businesses.
- *IO-Phenotype 3* is defined by a quite narrow technology portfolio and a diversified product base: This pattern is symptomatic for companies following a 'technology based' product diversification strategy. Companies, such as Sony or Philips in the consumer electronics industry, use their generic technological resource base to develop new products for a variety of markets.
- *IO-Phenotype 4* is characterized by focused technology and product portfolios: This pattern is typical for companies from the pharmaceutical cluster. Almost all pharmaceutical companies in the sample have focused on the drug business and divested other business, like chemicals, agro and food. At the same time they have concentrated their activities on a few related technology fields, such as organic chemistry, pharmaceutical technologies and biotechnologies.

Figure 9 summarizes the key characteristics of the four IO-phenotypes described above in an idealized way.

--- Put Figure 9 about here ---

Analogue to the analysis of the input/output diversification patterns in the sample we can now investigate the relationship between output diversification and international diversification (OG). Of course, a similar analysis and description of phenotypes could be done for the relationship between input diversification and international diversification (GI). Figure 10 visualizes the corporate output diversification and geographical diversification patterns at the end of the investigation period (1993-1997).

--- Put Figure 10 about here ---

Again, the comparison of geographical diversification and product diversification enables us to derive a typology of four different phenotypes (GO). Each GO-phenotype is characterized by a specific diversification pattern.

- *GO-Phenotype 1* is characterized by a focused product portfolio and by a diversified geographical portfolio: This pattern is symptomatic for companies that have focused on a limited number of products that require considerable investments in R&D and/or marketing. Since these investments are highly product specific, the companies are not able to realize economies of scope. For that reason they will not engage in product diversification acitivities but focus on geographic diversification. GO-Phenotype 1 is typical for companies from the pharmaceutical and specialty chemicals clusters.

- *GO-Phenotype 2* exhibits both a broadly diversified product and a broadly diversified geographical portfolio: Diversified electronic and machinery companies, typically European companies like Sulzer, Alcatel or ABB, are engaged in a large number of product fields and market their technologically competitive (niche) products on a global scale.
- *GO-Phenotype 3* is defined by a quite narrow geographical portfolio and a diversified product base: This pattern is symptomatic for diversified Japanese electronic companies, like Mitsubishi Electric, Hitachi, NEC or Toshiba. The majority of their products is designed for the domestic market. Only a small number of the products competes on a global scale, e.g. in the European and North American marketplace.
- *IO-Phenotype 4* is characterized by focused geographical and product portfolios: This pattern is typical for only a few companies. In our sample, for instance, both U.S.-based automotive manufacturers are characterized by this diversification pattern.

Paths in the Evolution of Corporate Diversification Patterns

From a dynamic perspective the question arises how these diversification patterns evolved over time. In the course of the three five years periods of investigation the static patterns of corporate diversification translate into distinct paths of evolution. Again, and even more surprisingly, it can be shown that there are concurrent paths in the evolution of corporate diversification among the sample companies. E.g., companies that belong to the same technology clusters exhibit a considerable degree of homogeneity in their paths of evolution. As a representative example for all diversificiation pairings (IO, GO, GI), figure 11 gives an overview of the paths of evolution of corporate IO-diversification. For reasons of lucidity we have visualized the paths for a limited number of 20 sample companies.

--- Put Figure 11 about here ---

From all three perspectives (IO, GO, GI), the paths in the evolution of the corporate diversification patterns can be assigned to two different categories: On the one hand, we have identified paths of evolution that evolve only slowly over ,time and on the other hand we have spotted trajectories that change more radically. In the case of stable diversification patterns, both the degree of product diversification, the degree of technological diversification and the degree of international diversification remain more or less stable over time in relation to the sample average. Stable diversification patterns apply to the majority of the sample companies and can be found in the chemical cluster, in parts of the pharmaceuticals cluster, in the computer and electronics cluster as well as in the systems engineering cluster. Most of the companies have expanded their range of activities and changed their technology and product portfolios only gradually. In contrast to continuity, some companies with dynamic diversification patterns, like Nokia and Ericsson, have shifted the range of their product and/or technology and/or geographical portfolio more dramatically. Clear signs of shifts in the range of products become also evident in the pharmaceuticals cluster.

Concluding Remarks: An Evolutionary Perspective on Diversification

We conclude our phenomenological analysis of corporate diversification patterns by setting the agenda for a model to explain the observed diversification trajectories. A model that aims to explain the observed paths in the evolution of corporate diversification patterns should be able to provide a theoretical rationale for the both eye-catching observations we have made:

- Most of the diversification profiles change slowly and only gradually over time. What explains these signs of path dependencies? Why do some firms change their diversification patterns more radically?
- Despite big differences in size, home country, history etc. there clearly prevails a high degree of homogeneity not only among the individual diversification patterns but also among the individual paths of evolution of the companies that belong to the same clusters. Which factors can help to explain these concurrent trends?

To answer these questions one ha to specify a dynamic model of corporate diversification. This means constructing a model that can predict patterns of change, including rates of change (the speed at which change occurs) and alternative paths of change. Taking an evolutionary perspective on corporate diversification thus means developing a dynamic, path-dependent model that allows for possible random variation among the corporations (see also Barnett and Burgelman, 1996). More specifically, a dynamic model of corporate diversification should include three core elements:

(a) First, propositions about cause-effect-relationships between product diversification, technological diversification and geographical serve as a basic framework. The propositions address important motivations for diversification. More commonly, random development represents a baseline model serving as the null hypothesis.

(b) Second, propositions about related versus unrelated diversification moves incorporate dynamic elements about the direction and rate of changes in the diversification patterns into the model. Path dependencies and lock-in phenomena can be illustrated with these propositions.

(c) At last, propositions about interdependencies between input, output and geographical diversification steps will explicitly focus on feedback loops between the three dimensions. While most research on diversification has focused on products or business diversification, only few studies have addressed the dynamic interplay between input- and output diversification as well as input diversification and international diversification.

References

Barnett, WP, Burgelman, RA. (1996). Evolutionary Perspectives on Strategy. *Strategic Management Journal* 17/5, 5-19.

Breschi S, Lissoni, F, Malerba, F. (1998). *Knowledge Proximity and Technological Diversification.* CESPRI Discussion Paper. Universita L. Bocconi: Milan.

Department of Trade and Industry (DTI). 2001. *The UK R&D Scoreboard 2001*. Company Reporting Limited: Edinburgh.

Fai, FM. (1999). The evolution of corporate technological diversification 1930-90: An investigation into the concept of technological relatedness. *Communication to European Meeting on Applied Evolutionary Economics.* 7-9 June 1999. Grenoble.

Gavetti, G. (1994). *Strategies of Multinational Firms in the Patent Domain in Europe*. Working paper for the Commission of the European Communities. Milan.

Granstrand, O. (1998). Towards a theory of the technology-based firm. *Research Policy* 27/5, 465-490.

Granstrand, O, Oskarsson, C. (1994). Technology Diversification in „MUL-TECH“ Corporations. *IEEE Transactions on Engineering Management* 41/4, 355-364.

Granstrand, O, Sjölander, S. (1990). Managing innovation in Multi-Technology Corporations. *Research Policy* 19/1, 35-60.

Jaffe, AB. (1989). Characterizing the "technological position of firms, with application to quantifying technological opportunity and research spillovers. Research Policy 18, 87-97.

Kim, WC., Hwang, P., Burgers, WP. (1993), Multinationals' Diversification and the Risk-return Trade-off, in: Strategic Management Journal 14/4, 275-286.

Kodama, F. (1995). *Emerging Patterns of Innovation: Sources of Japan's Technological Edge*. Boston, MA.

Markides, CC. (1996). *Diversification, Refocusing and Economic Performance.* Cambridge.

Oskarsson, C. (1993). *Diversification and Growth in US, Japanese and European Multi-Technology Corporations.* Chalmers University of Technology: Goeteborg.

Patel, P, Pavitt, K. (1998). The Wide and Increasing Spread of Technological Competencies in the World's Largest Firms: A Challenge to Conventional Wisdom. In: Chandler A. et al. (eds). *The Role of Technology, Strategy, Organization, and Regions*. Oxford.

Pavitt, KL. (1988). Uses and Abuses of Patent Statistics. In AFJ van Raan (ed), *Handbook of Quantitative Studies of Science and Technology*, Amsterdam.

Praest, M. (1998). Processes of Technological Competence Accumulation: A Synthesis. Paper prepared for the DRUID summer conference. 9th-11th of June 1998. Bornholm.

Sambharya, R.B. (1995), The combined effect of international diversification and product diversification strategies on the performance of U.S.-based multinational corporations, in: Management International Review 35/3, 197-218.

Schmoch, U. (1999). Impact of international patent applications on patent indicators. *Research Evaluation* 8/August, 119-131.

Sjölander, S, Oskarsson, C. (1995). Diversification: Exploiting the Flow of Technology. A Swedish comparison. *International Journal of Technology Management* 10/1, 21-31.

Stephan, M, Pfaffmann, E. (2001). Detecting the Pitfalls of Data on Foreign Direct Investment: Scope and Limits of Foreign Direct Investment Data, *Management International Review,* 41/3.

Figure 1. OST/INPI/ISI-technology Classification Defined by IPC symbol

I. Electrical engineering	II. Instruments	III. Chemistry, Pharmaceuticals	IV. Process engineering	V. Mechanical engineering
Electrical machinery and apparatus, electrical energy	Optics	Organic fine chemistry	Chemical engineering	Machine tools
Audio-visual technology	Analysis, measurement, control technology	Macromolecular chemistry, polymers	Surface technology, coating	Engines, pumps, turbines
Telecommunications	Medical technology	Pharmaceuticals, cosmetics	Materials, metallurgy	Thermal processes and apparatus
Information technology	Nuclear engineering	Biotechnology	Materials processing, textiles, paper	Mechanical elements
Semiconductors		Agriculture, food chemistry	Handling, printing	Transport
		Chemical and petrol industry, basic materials chemistry	Agricultural and food processing, machinery and apparatus	Space technology, weapons
			Environmental technology	Consumer goods and equipment
				Civil engineering, building, mining

Figure 2. Technology Clusters in the Sample (1993-1997 Period)

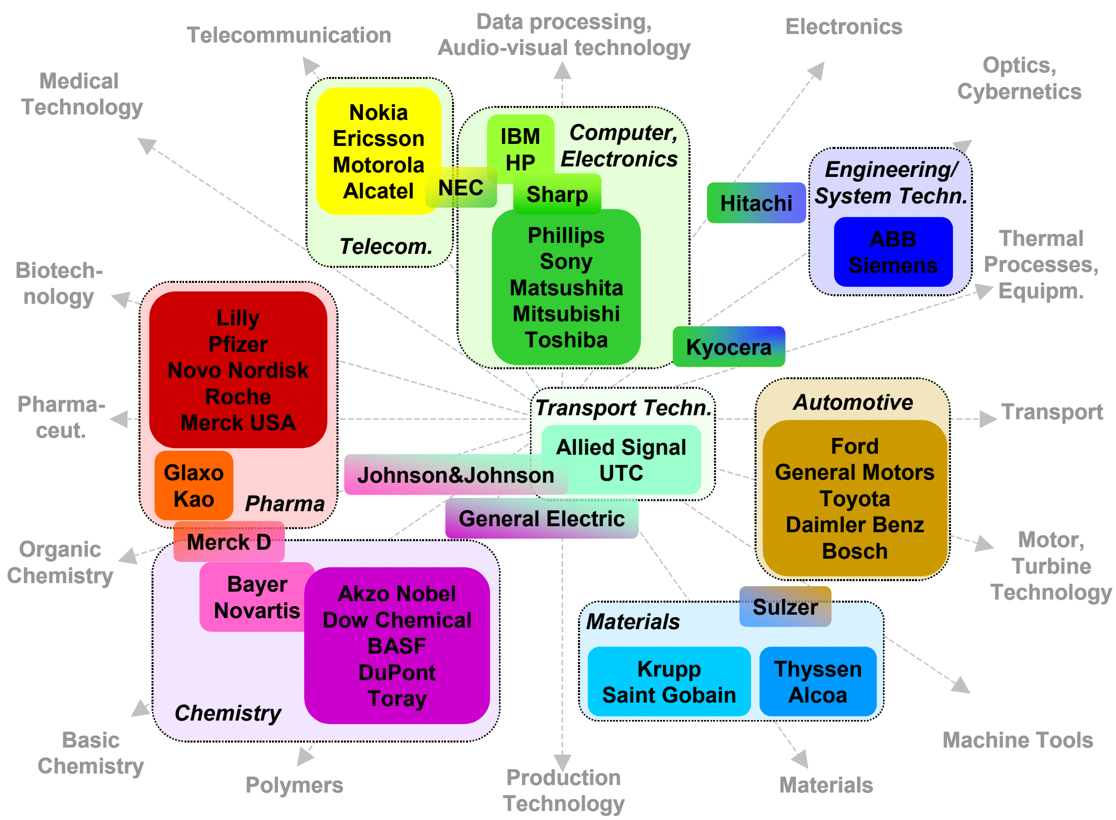

Figure 3. Product Clusters in the Sample (1993-1997 Period)

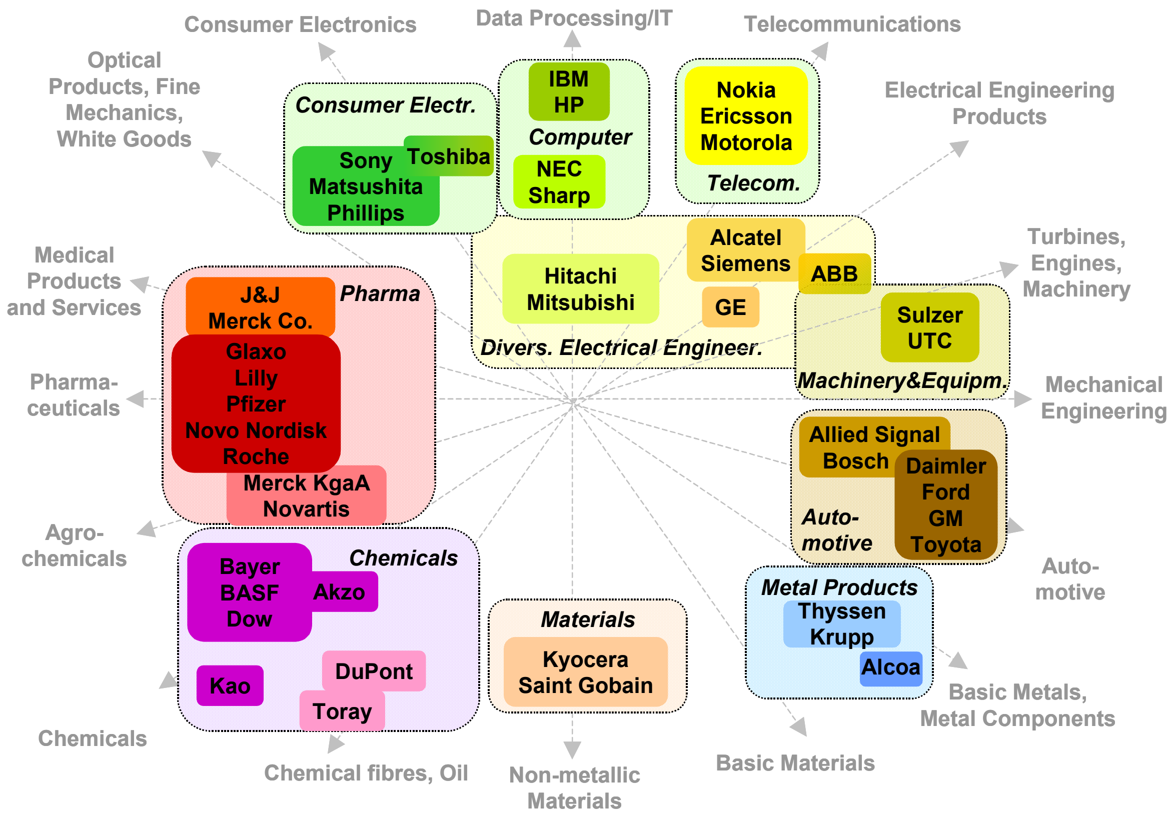

Figure 4. Trends in (Unrelated) Technological Diversification in the Sample Differentiated by Industry Clusters

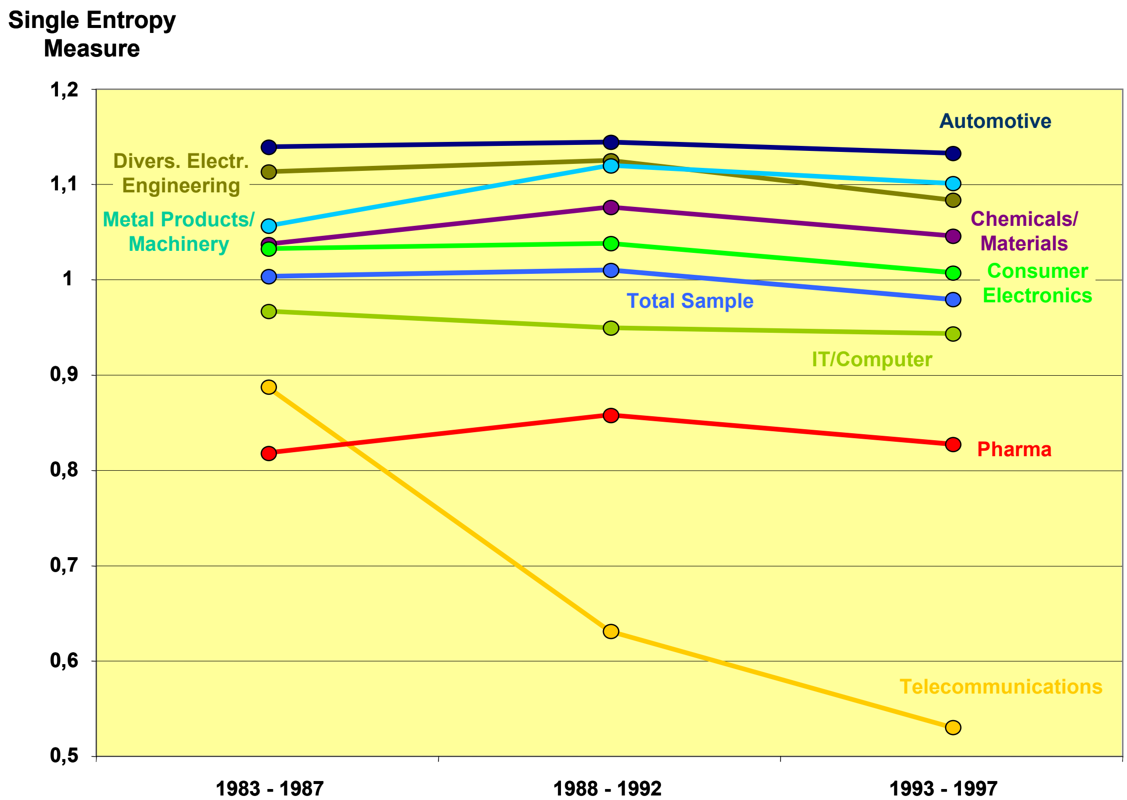

Figure 5. **Trends in (Unrelated) Product Diversification in the Sample Differentiated by Industry Clusters**

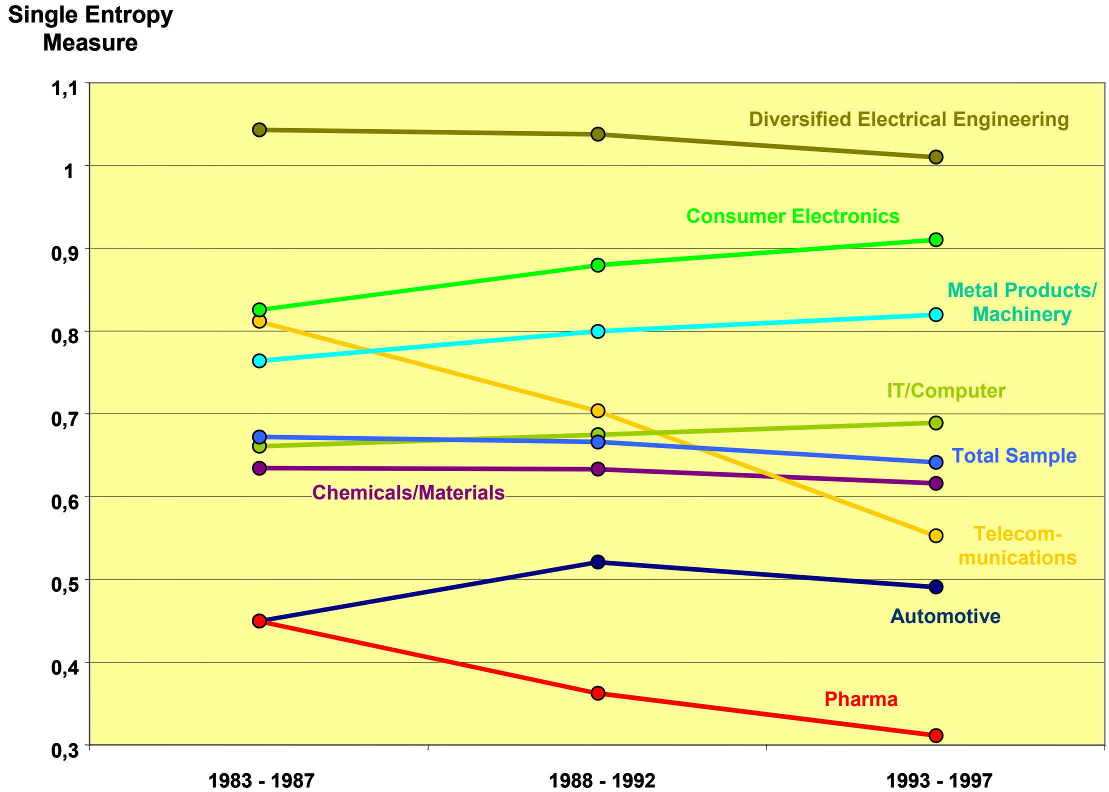

Figure 6. **Trends in International Diversification in the Sample Differentiated by Home Country**

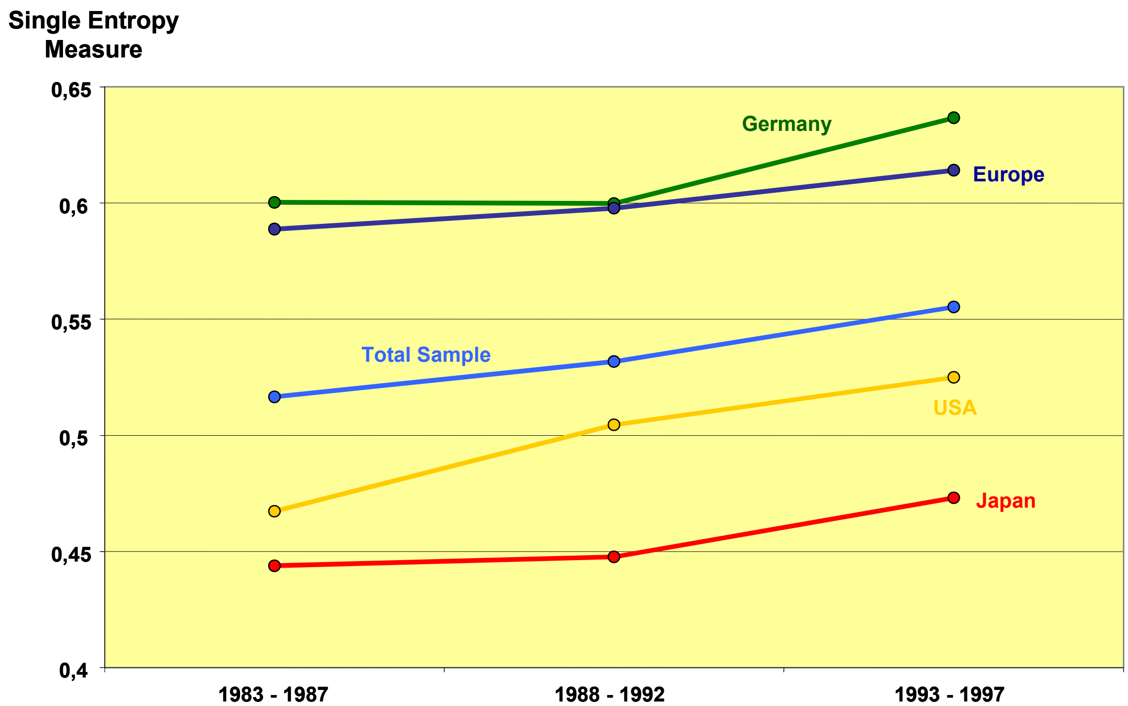

Figure 7. **Trends in International Diversification in the Sample Differentiated by Industry Clusters**

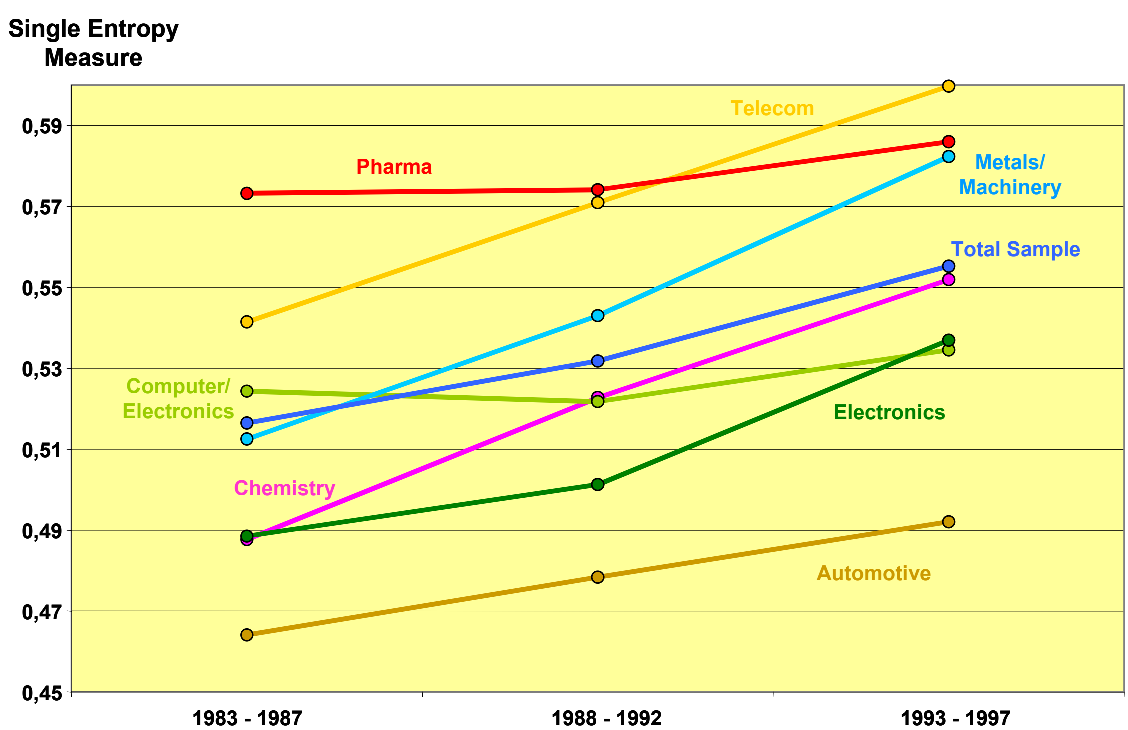

Figure 8: Phenotypes of Corporate Input and Output Diversification (1993-1997)

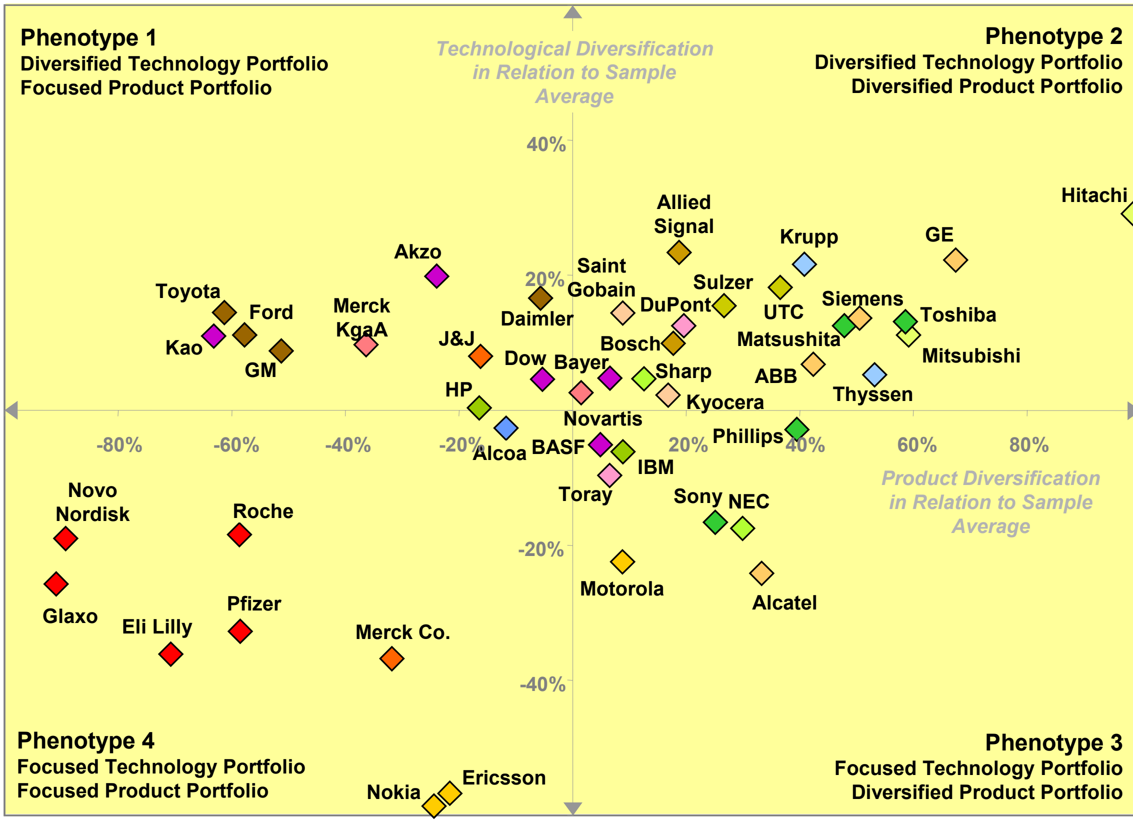

Figure 9 Typology of Input/Output Diversification Patterns

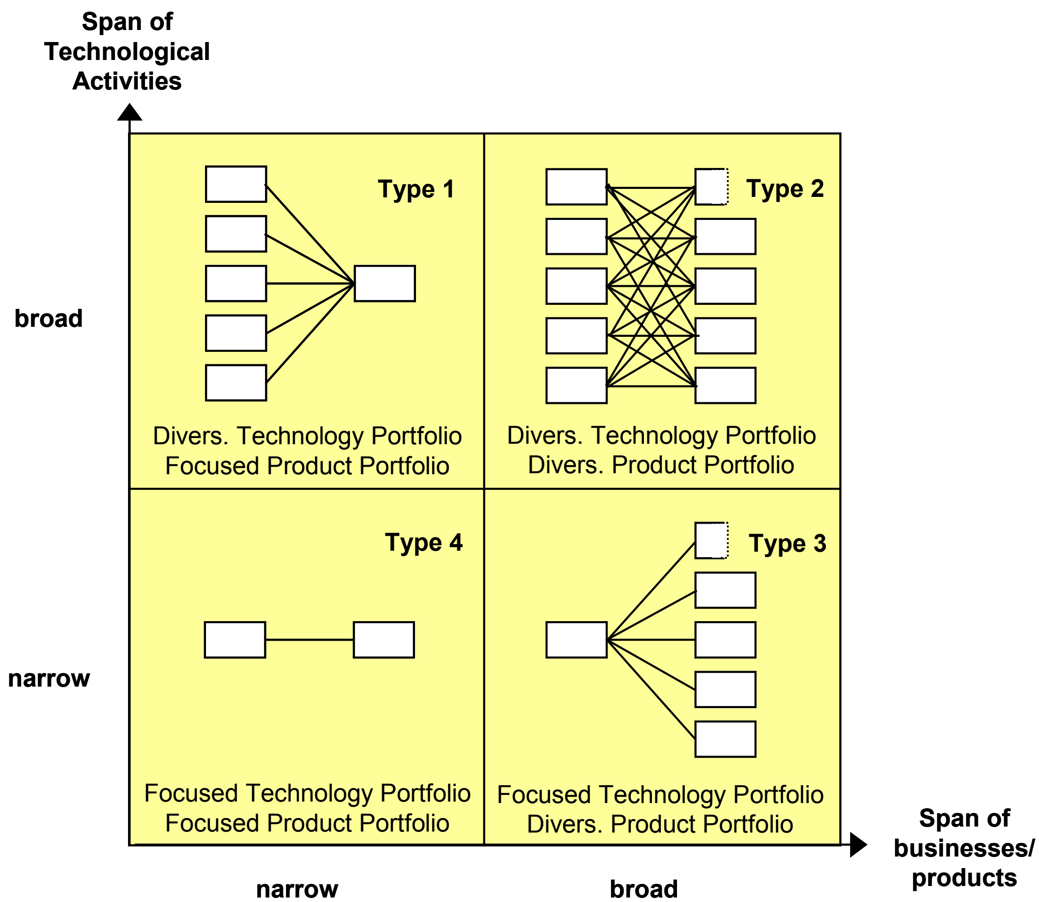

Figure 10: Phenotypes of Corporate Output and Geographical Diversification (1993-1997)

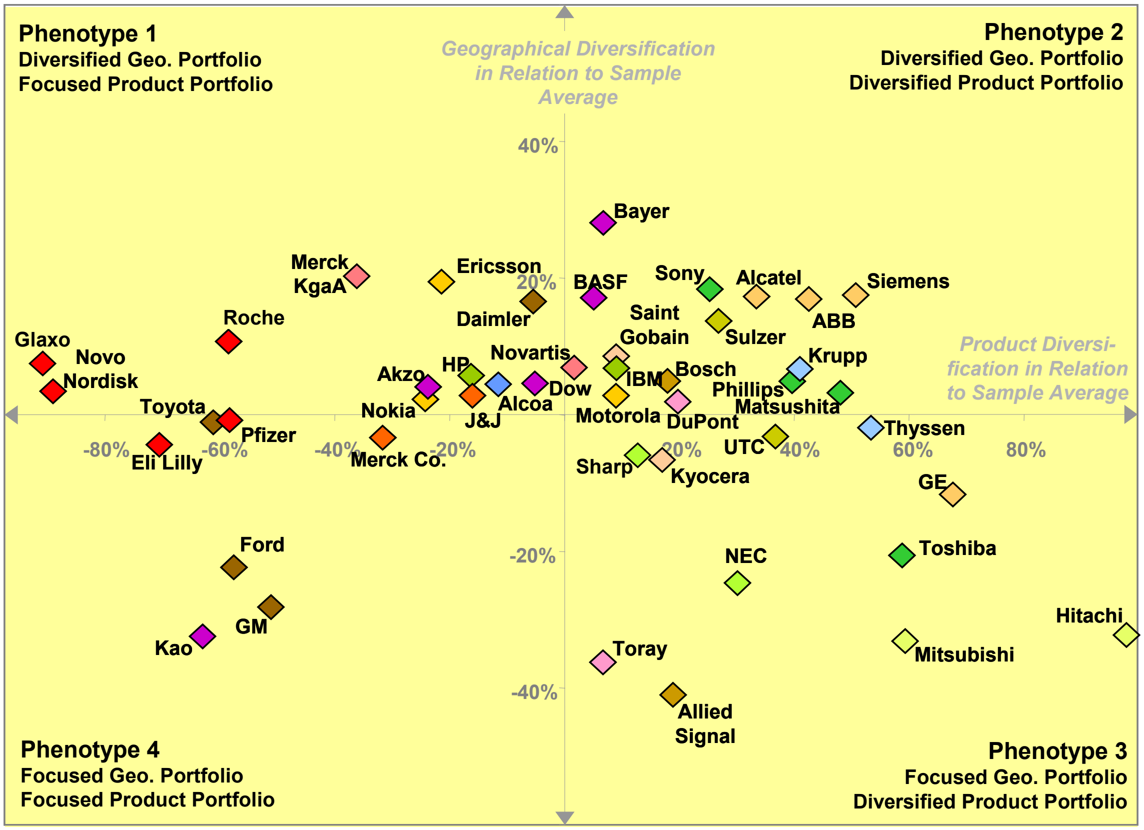

Figure 11: Paths in the Evolution of Corporate IO-Diversification (1983-1997)