

**WHU-Forschungspapier Nr. 86 (April 2002)**

**“An integrated portfolio approach to support  
market-oriented R&D planning”**

**Holger Ernst  
Jan Henrik Soll**

WHU  
Otto Beisheim Graduate School of Management  
Burgplatz 2  
56179 Vallendar

Internet: [www.whu.edu/tim](http://www.whu.edu/tim)

Prof. Dr. Holger Ernst ist Inhaber des Lehrstuhls für Betriebswirtschaft, insbesondere Technologie- und Innovationsmanagement, der Wissenschaftlichen Hochschule für Unternehmensführung (WHU) - Otto-Beisheim-Hochschule, Vallendar.  
Dipl.-Kfm. Jan Henrik Soll ist wissenschaftlicher Mitarbeiter an diesem Lehrstuhl.



\* 408/2002 \*

# An integrated portfolio approach to support market-oriented R&D planning

Holger Ernst and Jan Henrik Soll

## Table of Contents

1	Introduction.....	2
2	Development of an Integrated Portfolio Concept.....	3
2.1	The Market Portfolio.....	3
2.2	The Technology Portfolio.....	5
2.2.1	The 'Classic' Technology Portfolio .....	5
2.2.2	The Patent Portfolio .....	6
2.3	The Integrated Portfolio.....	9
3	An Application of the Integrated Portfolio in the Chemical Industry.....	13
3.1	Data Collection and Measurements .....	13
3.2	Results of the Portfolio Analyses .....	14
4	Conclusions .....	17
	References .....	19

**Abstract:** Marketing and R&D strategies need to be aligned to increase the return from investment in new technologies. Various portfolio techniques have been widely used to support strategic planning. In order to balance Marketing and R&D in the strategic planning process it is necessary to integrate different portfolio concepts. A new portfolio approach integrating market and technology portfolio to support market-oriented R&D planning is developed. The integrated portfolio is based on objective market and patent data and empirical evidence that the respective portfolio dimensions impact a company's business performance. This contributes significantly to the relevance of the proposed integrated portfolio approach for strategic planning. The integrated portfolio is tested in a practical application in the chemical industry. Based on these experiences a set of recommendations for the effective use of the integrated portfolio for market-orientated strategic R&D planning are derived.

## 1 Introduction

Market orientation is a key driver of company performance [1]. Accordingly, companies should align their core activities with market requirements. Among a company's most important activities is the development and market introduction of new products because it determines sustained company success in many industries [2,3,4]. It has been frequently shown that the alignment of all process steps from idea to launch with market requirements is a success factor of new product development [5,6,7]. Consequently, research and development (R&D) should be focused on designing new products which satisfy market requirements.

Technological change has been found to have a decisive impact on the competitive structure in many industries [8,9,10]. In the US hard-disk drive industry it was shown that companies, having previously dominated the market, were driven out of this market by missing a new, disruptive technology which was aggressively pushed by new competitors [11]. Thus, even if market requirements remain basically unchanged, technological progress can severely effect a company's competitive position. These changes need to be identified and assessed as early as possible in order to align the firm's R&D strategy accordingly [12,13,14]. Thus, market requirements and technological capabilities need to be assessed simultaneously in order to formulate effective strategies for new product development.

The integration of market requirements and technological capabilities has to be achieved on all management levels. On the project or process level, measures to overcome interface problems, e.g. the establishment of cross-functional teams [15], or measures to foster interdepartmental communication, e.g. by using quality function deployment [16], help to avoid that one specific functional perspective dominates the new product development process which could result either in incremental innovation lacking significant long-term returns to the firm or in high-end technological solutions not accepted or valued by the market [17]. It has been shown in empirical studies that the integration of market requirements and technological capabilities during new product development increases success [18,19]. At the same time, integration ought to be achieved also on the strategic level, i.e. Marketing and R&D strategy must be aligned [17]. There is empirical evidence that a strategy which balances market requirements and technology capabilities leads to higher new product success [20,21].

To support strategic planning various portfolio concepts have been developed over the years. In the 1970s market portfolios became popular to support strategic planning in large corporations. However, a product's underlying technologies were not assessed in market portfolios which posed the danger to overlook technological changes and to make wrong investment decisions. Consequently, technology portfolios were developed in the 1980s to assess technologies according to their competitive impact [12,22]. However, technology portfolios lack an explicit market focus. In addition, substantial deviations of subjective assessments required for drawing market as

well as technology portfolios have had a negative impact on the effectiveness of these portfolios for strategic planning purposes [23]. Thus, the need arises to integrate market and technology portfolios based on objective data in order to achieve a better alignment of Marketing and R&D strategies in companies. In this paper, we first develop such an integrated portfolio approach to support market-oriented R&D planning (section 2). Subsequently, we test the proposed portfolio method in a practical application (section 3). This paper concludes with an evaluation of the proposed portfolio method and with suggestions for further applications in section 4.

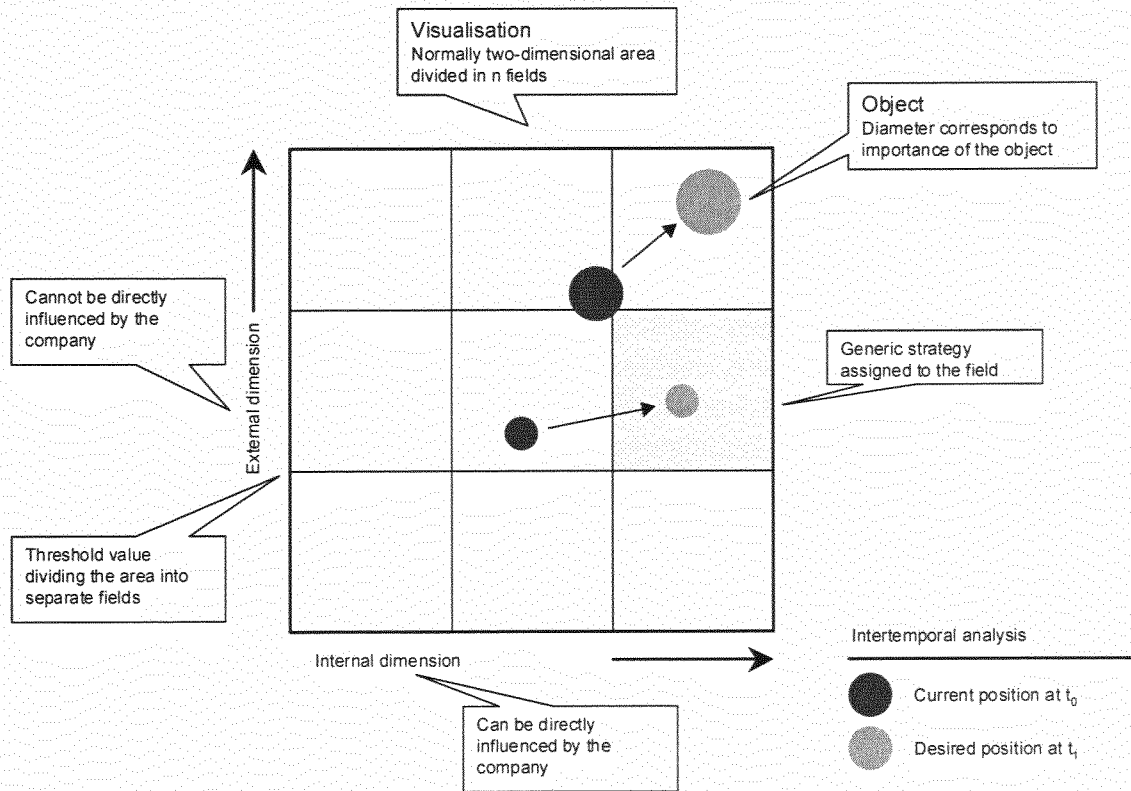
## **2 Development of an Integrated Portfolio Concept**

### *2.1 The Market Portfolio*

The concept of product portfolio analysis is one of the most widely used tools in the field of strategic planning. Its origins date back to the late sixties when diversified companies were facing an increasingly complex strategic planning process. Therefore, companies had to find new ways to assure an effective and efficient management of the company's resources. The Boston Consulting Group developed its market share/market growth matrix for this purpose. It is still the most widely known and implemented approach [24,25]. It enables managers to easily comprehend and communicate a complex problem, thus having a powerful tool supporting strategic decision making.

Subsequently many variants of this approach were developed, yet all varying the same basic structure [26]. All share a two dimensional framework with one dimension representing the competitive position in the respective market and the other one dimension illustrating market attractiveness (see figure 1 for a depiction of a generic portfolio). The dimensions are either univariately or multivariately defined. The area spanned up by the dimensions is divided into four or more fields, each of them being assigned a generic strategic recommendation for the products or business units being positioned in the respective area. The size of the circles representing products or strategic business units is usually determined by the respective share of sales or a measure of profitability.

The market share/market growth approach is a sound concept regarding required data and underlying assumptions. It has been subject to much empirical research providing supporting evidence [27,28]. The use of market share is based on the positive correlation with profitability as identified in the Profit Impact of Market Strategy (PIMS)-study [29,30]. In most cases, relative measures are used, i.e. the company's market share in relation to its strongest competitor. The use of market growth draws on the product life-cycle concept [31]: young markets being attractive in the long run show larger growth rates than mature markets. It is less costly to gain market share in these markets, as market share increases in mature markets are necessarily achieved at the expense of a competitor and are usually vigorously



**Figure 1** A generic portfolio matrix

resisted. The required data is relatively easy to capture: market share and market growth can be objectively measured, the only problem being the correct definition of the relevant market [32].

However, critics quickly argued that the underlying assumptions are flawed. Indeed, there is empirical evidence that the relationship between market share and profitability is not as clear-cut as postulated in the generic strategies of the portfolio matrix [24]. Moreover, it is often argued that the data basis is too weak to make profound strategic decisions. This led to the development of product portfolio concepts using multidimensional dimensions such as the market attractiveness/market position matrix developed by McKinsey [33]. In addition to market share, it uses a multitude of factors identified in the PIMS project. The factors are both qualitative and quantitative and thus harder to measure. The estimation of qualitative variables may lead to biases due to the subjective nature of the respondent's opinions. This may also distort the condensation of several factors into one construct representing the dimension which requires the definition of weighting factors [12]. Ideally, these would be derived from a factor analysis specific to each application. In practice, however, these are often set arbitrarily.

Thus, one faces a trade-off between a simple concept incorporating few variables which can be objectively measured or a complex model requiring data which is hard to capture, thus leaving room for biases. When using the approaches based on few variables it is important to keep in mind the limited data base in the simpler ap-

proaches on which the generic strategies are recommended. Generally, the results of most approaches are very sensitive to different operational definitions of the dimensions and the measurement methods. Their selection and subsequent validation is most important because of the direct effect on the results of the analysis. There is empirical evidence that minor changes in definition may lead to very different results [34].

Apart from these issues being more technical in nature, there is substantial criticism highlighting a central drawback of market portfolios. As they capture the market positioning of the company's products or strategic business units and their respective current competitors, product portfolio analysis is essentially short-term oriented. It fails to capture external turbulences such as new technologies which affect the positioning in the portfolio and thus the recommended strategies. Moreover, the generic strategies maximize short to medium-term profitability with their recommendations. In order to maintain the long-term competitive position the company has to check for potential substitutes based on new technologies not captured in the portfolio.

## 2.2 *The Technology Portfolio*

### 2.2.1 The 'Classic' Technology Portfolio

Given the apparent shortcoming of the product portfolio concept to incorporate the competitive dynamics of technological change, different authors developed so-called technology portfolios [12,22]. They generally have the same structure as market portfolios with two multivariate dimensions (see also figure 2 for an illustration of a specific form of technology portfolio):

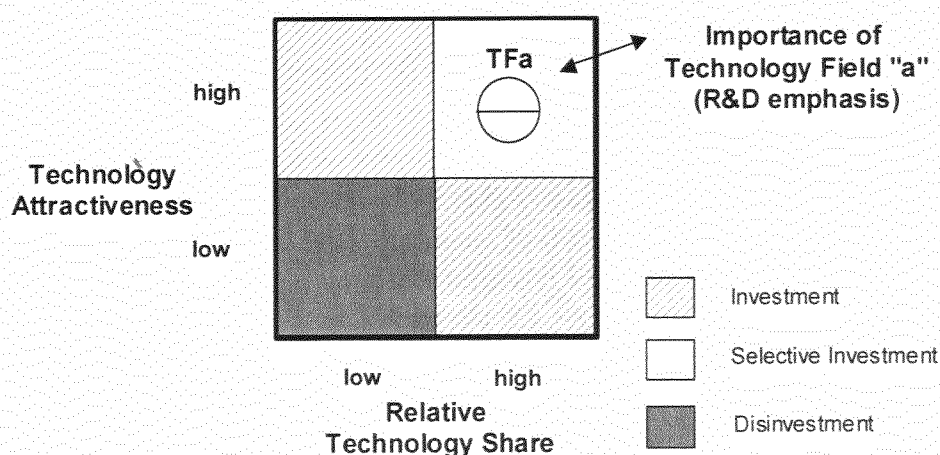
The first dimension of a technology portfolio, usually named "technology attractiveness", incorporates external factors indicating the potential of a technology to impact the competitive position of the firm. The second dimension, usually named "relative technological position" is an internal construct whose variables can be influenced by the firm and indicates its capabilities or competencies in a specific technology. Most approaches lack the sound theoretical underpinning from empirical studies as in the case of product portfolios like the PIMS-study and the extensive research into the product life cycle. Thus, the generic strategies suggested in technology portfolios seem less valid than those for product portfolios.

As technologies and technological progress are generally hard to assess, most approaches rely on a multitude of qualitative factors which are condensed into one construct using a scoring model [12,22]. In addition to the criticism relevant for all types of portfolio models, especially the fact that technology portfolios entirely build on subjective evaluations have called for heavy criticism [35]. It has been shown that perceptions of informants from R&D and Marketing on various aspects related to new product development and technology can deviate significantly. Thus, a so-called informant bias can lead to systematically distorted answers [36]. Practical applica-

tions of the technology portfolio method thus show that experts from Marketing and R&D substantially differ in their assessments of both portfolio dimensions [23]. These problems might partially be offset by using multiple experts. Nevertheless, the aggregation of multiple judgements poses yet another potential source of systematic distortion of the results. It is thus suggested to use less but objective data to overcome these problems in patent portfolios [35].

### 2.2.2 The Patent Portfolio

Patent data and patent statistics have long been used by economists as a proxy for technological change and technological process. There is significant empirical evidence supporting the validity of this approach [37]. They can also be used to assess an individual company's technological positioning. Patent data have the big advantage that they are widely available and objective in nature. In a further step entire portfolios assessing a company's patent position were proposed [38,39]. These assign the company's patents to different technology fields relevant to the company and evaluate them afterwards using different indicators entirely based on patent data. The use of patent data overcomes the central weakness of the technology portfolio concept based on subjective evaluations. Both concepts share the same basic structure with one dimension assessing technological position and the other one assessing technology attractiveness. In contrast, the operational definition of the variables now exclusively draws on patent data as input source [39]. As patent portfolios (see figure 2) will be an important element of the integrated portfolio concepts developed later on in this article, we will briefly describe the indicators used to assess technological positions. For a more detailed description, please refer to the articles by Brockhoff and Ernst [38,39].



**Figure 2** The patent portfolio

In analogy to the market growth/market share portfolio, early variants of the patent portfolio used a measure called "relative patent position" as the internal dimension on the abscissa. It is calculated as the number of patent applications of the company in question for the respective technology field divided by the number of patent

applications of the most active competitor in this technology field [38]. In later works it has been suggested to use the term "relative technology share" in order to describe the competitive technological position in analogy to "relative market share" commonly used to measure a firm's competitive position in the market [40].

As this is a measure only incorporating patenting activity, but not accounting for the quality of patents, other operational definitions of the internal dimension have been proposed. Empirical studies prove that there is a significant positive correlation between indicators of patent quality and economic success [41,42,43,44,45]. Accounting for patent quality is an important link to establish an analogy between patent and market portfolios: both, relative market share and relative technology share incorporating patent quality, have a positive impact on a company's business performance. The following indicators are widely suggested to be used for assessing the quality of patents:

1. Rate of patents granted: A patent will be granted only if the invention consists of new technological elements. Thus, a patent is believed to have a higher technological value than the patent application [46]. The rate of patents granted substantially differ between companies and can thus serve as an indicator for the quality of research. The rate of patents granted is measured as the number of patents granted divided by the number of patent applications less the number of patent applications currently under examination.

2. International scope of patent applications: As the cost for obtaining an internationally valid patent is significantly higher than that of a national patent, they have been empirically found to be of higher value than national applications only [37,45]. Applications in the US have frequently been used in the literature to measure patenting quality. For German companies, there is empirical evidence that their share of US or European patents correlate with commercial success [39]. The selection of an appropriate patenting indicator for international scope depends on the companies contained in the sample.

3. Patent Citation Ratio: Patents are used by patent inspectors at the patent office to document the state of technology when they check if a patent application contains new features which go beyond what has been known so far. This procedure leads to patent citations. The number of citations received by a patent in subsequent patent documents is often interpreted as a sign for an economically important invention [47,48,49]. The average citation ratio can be computed by dividing the number of citations by the total number of patent applications [50].

Therefore, a construct for patent quality consisting of different quality measures is used in newer approaches to assess the technological impact [45]. The use of different measures allows to achieve a stable assessment of a company's patent position [35]. Ideally, weights for each single indicator of patent quality should be determined based on each indicators' prediction a patent's economic value. The economic value of patents should be assessed on their contribution to sales or profit margins derived



from products protected by these patents. "Relative Technology Share" (RTS) is defined as follows:

$$(1) RTS_{if} = PP_{if} / PP_{i^*f}$$

$$(1a) PP_{if} = PA_{if} \circ PQ_{if}$$

$$(1b) PQ_{if} = \sum_{k=1}^K PQ_{ifk} \bullet w_k$$

with the following parameters:

PA = number of patent applications; PP = patent position; PQ = patenting quality; i = company (i = 1,...,I);

i\* = competitor with strongest patent position (benchmark); k = indicator of patenting quality (k = 1,...,K);

f = technology field; w = weight of quality indicators.

The external dimension 'technology attractiveness', which is displayed on the ordinate, is measured by the growth rate of patent applications in the respective technology field. Usually, recent patent growth is measured relative to previous patent growth in order to capture the latest development trends in technological change. Using patent growth as a proxy for a technology's attractiveness is supported by empirical studies showing a strong correlation between patent and market growth in various industries [13,45,51]. Furthermore, relative growth rates are calculated, i.e., patent growth in a specific technology field is divided by the average patent growth of all technology fields contained in the analysis. It is important to note, as it is the case for market portfolios, that different measures of patent growth can lead to diverging positionings in the patent portfolio and hence other strategic recommendations [35,39]. "Technology attractiveness" (TA) based on patent growth is defined as follows:

$$(2) TA_f = PG_f / PG_R$$

$$(2a) PG_f = PG_{ft-\tau} / PG_{ft-\theta}$$

$$(2b) PG_R = PG_{Rt-\tau} / PG_{Rt-\theta}$$

with the following parameters:

PG = patent growth; t = reference point for time interval;  $\tau$  = time lag for numerator (recent patent growth);

$\theta$  = time lag for denominator (preceding patent growth); f = technology field; R = reference to measure relative growth rates.

The third dimension represented by the circle size of the technology fields in the patent portfolio is called "R&D emphasis". "R&D emphasis" is calculated as the total number of patent applications of the company in one technology field divided by the total number of all patent applications of the respective company. Thus, "R&D emphasis" indicates a technology's importance in the company's total R&D portfolio. "R&D emphasis" (RDE) is defined as follows:

$$(3) RDE_{if} = PA_{if} / PA_i$$

with the following parameters:

PA = patent applications; i = company (i,...,I); f = technology field.

In contrast to other technology portfolios, generic strategies for the patent portfolio have been isolated in extensive empirical research [45]. These largely correspond to the generic strategies of the market growth/market share portfolio, e.g. to aggressively invest in technology fields with high growth and strong positions, i.e. high impact pacing and key technologies. Thus, the patent portfolio is the only technology portfolio grounded on a sound empirical basis.

Despite this fact, patent portfolios share the most important drawback with classic technology portfolios. R&D planning is only one aspect of strategic planning. It necessarily leads to the misappropriation of resources if only technological aspects are considered in the planning process. Therefore, they need to be aligned with other strategic planning tools in order to avoid one-sided technology-dominated misconceptions. This is why several integrated portfolio concepts have been proposed in the literature.

### 2.3 The Integrated Portfolio

Pure technology or market portfolios have a one-sided focus on either technology or product market. We already elaborated on the importance of market orientation in the R&D process in section 1. New technologies have to fulfil market needs. Otherwise products based on them will fail in the market. The integrated portfolio concepts trying to overcome this shortfall by combining market and technological analysis can be classified into three distinctive groups:

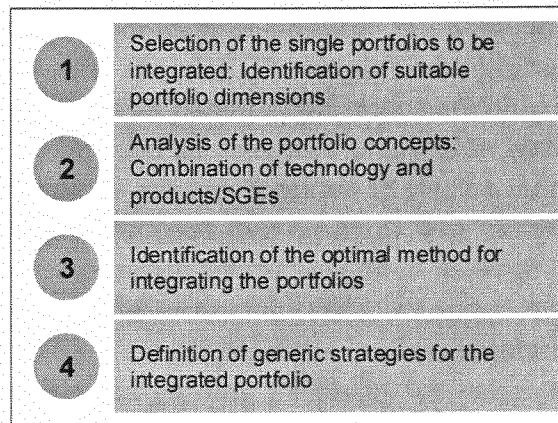
The first group builds upon an existing technology or market portfolio and add generic strategies for the missing perspective [24,52]. Although this approach is intriguingly simple, it does not solve the central problem of incorporating the interdependencies. The approaches fall short of providing a thoroughly integrated analysis and thus cannot fulfil the basic requirements. They cannot provide a valid tool for integrated R&D and market planning as they do not incorporate any quantitative or qualitative analysis of the missing dimension [12]. Applying similar strategic recommendations will only be valid if both technology and product are positioned in the same field of the portfolio. In all other cases, this will lead to a misallocation of resources and could even result in eroding the company's competitive base.

A second class of concepts develops entirely new portfolio approaches. Some of them use the classic matrix-type visualisation [53], while others use entirely different approaches for the formulation of the optimisation problem. Some approaches in the latter category either use a mathematical formulation of the portfolio problem and usually have a very stringent general formulation [54]. The general formulations would need to be adapted to the specific conditions in most practical applications. Given the often complex mathematical formulations and the generally low accep-

tance of mathematical optimisation problems in the corporate world, it is doubtful whether these approaches are of relevance outside theoretical discussions [55]. Other concepts use alternative methods like the analytical hierarchy process (AHP) to structure the problem [56]. These approaches need to be adapted individually for every implementation, i.e. they do not propose a generic portfolio which can be directly used, but a method to come up with individual portfolios. Being often rather complex and thus difficult to communicate and implement, these approaches lack practical relevance as well.

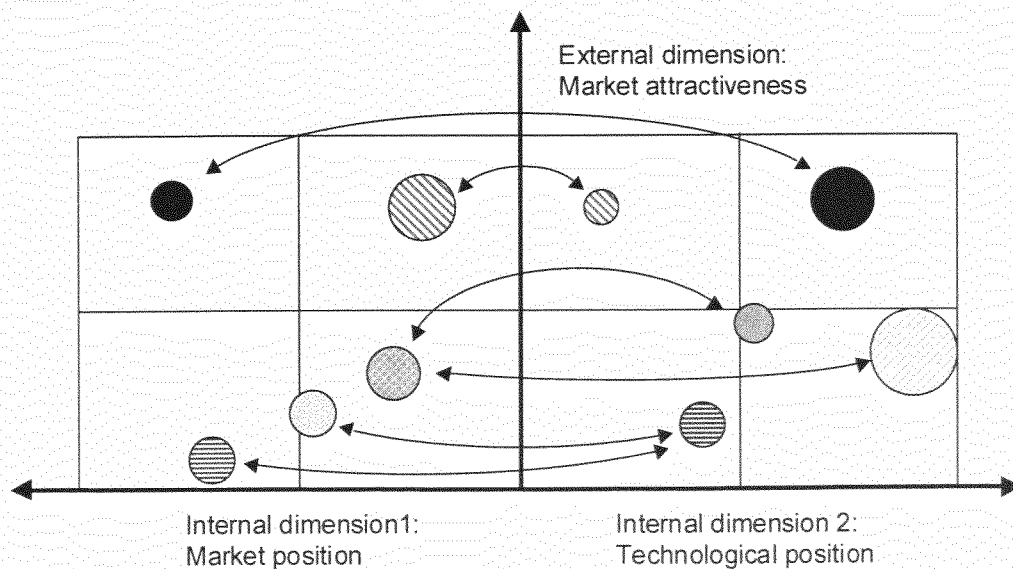
The third group of concepts tries to aggregate two or more single portfolios into one holistic portfolio. This could either be a new single matrix-type portfolio, i.e. a condensation of four dimension into only two. This procedure leads to a visualisation which is easy to understand and to communicate, but encounters several methodological problems. Most severely, a positioning in the aggregated portfolio cannot be traced back to distinctive positionings in the original portfolios, i.e. the same generic strategies would be applied to products and technologies positioned completely different in the market respectively technology portfolios [38]. Another approach is the integration using a common axis. Generally, this type of integration is theoretically sound as no data is omitted and the original portfolios remain largely unchanged. Their added value is the development of new integrated generic strategies. However, the amount of required data for the analysis can be quite massive, thus impeding practical implementation. This is especially the case for a meta-type aggregation of a multitude of portfolios [57]. As the integration using a common dimension has significant advantages over other methods, we will develop an integrated approach using this design. We will keep the amount of required data within reasonable limits in order to achieve an easy implementation while simultaneously building onto a theoretically sound basis.

In the following, we introduce a framework for the creation of concepts for integrated portfolios and simultaneously develop a new portfolio. It draws on elements of a framework by Wind/Mahajan [27], however, it incorporates necessary changes for the formulation of an integrated portfolio concept (see figure 3). The process of developing our integrated portfolio concept follows these steps. First, the portfolios which are subsequently integrated into a single portfolio are identified. We already made a case for the use of patent portfolios instead of other technology portfolios, the biggest advantage being the sound empirical foundation and the objective data used by them. Therefore, a matching market portfolio which captures the advantages of the product portfolio needs to be identified. The only market portfolio entirely relying on objective data is the market share/market growth matrix. Another possibility, in case no objective data are available, would be a market portfolio using multivariate dimensions which require quantitative data, e.g., a modified version of the market attractiveness/market position matrix (see section 2.1).



**Figure 3** Schematic process for designing an integrated portfolio

In a second step, a suitable integration mechanism has to be found. The two single portfolios have four different dimensions. In order to come up with an integrated portfolio which can be easily communicated, the integration using a common dimension is desirable. We already argued that the reliability of the dimension representing technology attractiveness in the patent portfolio is rather limited. In order to emphasise the importance of market orientation in the R&D process (see section 1), we suggest using market growth in the integrated portfolio. This approach clearly follows the notion that the attractiveness of a technology has to be mainly judged on the basis of its market impact. The growth/share matrix is now easy to integrate as both portfolios share a common dimension (see figure 4).



**Figure 4** The integrated portfolio

The third step is the incorporation of possible interdependencies between technologies and products into the analysis. The single portfolios use products and technology fields for the analysis. If all patent applications are only incorporated in a single product, products can be used as objects of analysis in both partial portfolios. If some of the patent applications are incorporated in two or more products, products and technology fields have to be used (see figure 4). The attractiveness of a technology field would then be determined by the weighted average of the market growth rate of the products in which the technology field is applied. In this way all interdependencies between technologies and products can be captured. To assess new technologies not yet incorporated in existing products, we suggest using expert assessments to compensate for eventually missing quantitative market data. The data could then be used to display an integrated portfolio depicting the technology or product pipeline. As this type of analysis has to be based on qualitative data, objective market data should be used whenever possible. Each half of the proposed integrated portfolio is split into four quadrants: the dimension "market attractiveness" is divided by a hurdle growth rate, e.g. average sales growth or a sales growth target, the dimension "technology share" at a value of the relative technology share of 1, the "market share" dimension equally at a value of the relative market share of 1.

As a starting point for isolating generic strategies, those of the market share/market growth and patent portfolio are used for the eight quadrants of the integrated portfolios to make strategic recommendations. They are empirically well proven [26,39]. In the case of a positioning in the same quadrant in both market and patent portfolio, the combined generic strategies remain correct: for a product with a star/star positioning, increasing marketing and R&D expenditures are necessary to reinforce market and technological positions and to counter attacks from competitors.

However, the generic strategies cannot be simply combined in case of disparate positionings. These could be interpreted as evidence for a misappropriation of R&D and/or marketing expenditures. In this case, the underlying situation has to be carefully evaluated in order to derive effective strategic implications from the portfolio analysis.

Our proposed integrated portfolio concept can be based entirely on quantitative data. It is easy to implement as the collection of data for the patent portfolio can be automated as well as their assignment to products or technology fields. Its simple structure is easy to communicate and understand, thus meeting the prerequisites for an effective and efficient tool for the support of strategy formulation integrating market and technology perspectives. We will in the following report on a practical application of the integrated portfolio concept.

### 3 An Application of the Integrated Portfolio in the Chemical Industry

#### 3.1 Data Collection and Measurements

A first implementation of the proposed concept was carried out for two business units of a company operating in the specialty chemicals industry. For each unit, distinct product areas were defined. The entire analysis incorporates seven product fields and 22 products of Business Unit 1 and 3 product fields and 15 products for Business Unit 2. Here, we can only report on some characteristic results. The required patent data was supplied by the firm's patent department. Patent applications were assigned to product fields and individual products in a workshop with senior patenting experts from the company.

The indicators described in section 2.2.2 required to draw patent portfolios had to be calculated. The share of granted patents was measured based on granted patents at the German Patent Office and international scope was calculated as the share of triad patents, filed in Europe, the US and Japan simultaneously, because it was believed by the experts from the patent department that this would best capture patent quality in this industry.

In order to determine the quality weights for each indicator of patent quality the patent department was asked to assess the economic value of each patent with respect to its contribution to profitability. Since this proved to be difficult for each single patent a group of economically very important patents ( $n = 33$ ) was identified by company officials. In addition, we randomly picked another 33 patents from the firm's patent portfolio as a control group. Table 1 shows the results of a logistic regression analyses between the two groups of patents. It can be inferred from the results that citations and the international scope of patent applications best predict group membership of patents. The regression coefficients have almost the same magnitude which justifies the assignment of equal weights to both indicators of patent quality. Interestingly, the patent grant does not predict group membership. This result is caused by the fact that almost all patents in the data set had been granted, thus adding no variance to the data. The statistical quality of the regression analysis is satisfactory, where almost 83% of patents are classified correctly and  $R^2$  amounts to 70%.

Due to the very specialised nature of the business units' products, no market growth rates and market share data were available. Thus, we had to rely on expert evaluations instead. The dimensions market attractiveness, relative market share and revenue share driving the circle size in the market portfolio were evaluated using a questionnaire sent out to marketing managers asking for their estimation of relative market share in relation to the strongest external competitor, product market growth relative to the average growth in the business unit and product sales relative to the average sales per product in the business unit. The answers had to be made on a continuous Likert-type scale ranging from 0 to 4.

**Tables 1 and 2:** Results of the logistic regression analysis

<b>I. Group classification (n = 66)</b>	Group (important patents)	1 Group (control group)	2 % of cases correctly classified
Group 1 (important patents)	28	5	84,8
Group 2 (control group)	7	26	78,8
Total	35 (28)	31 (26)	66 (81,8%)

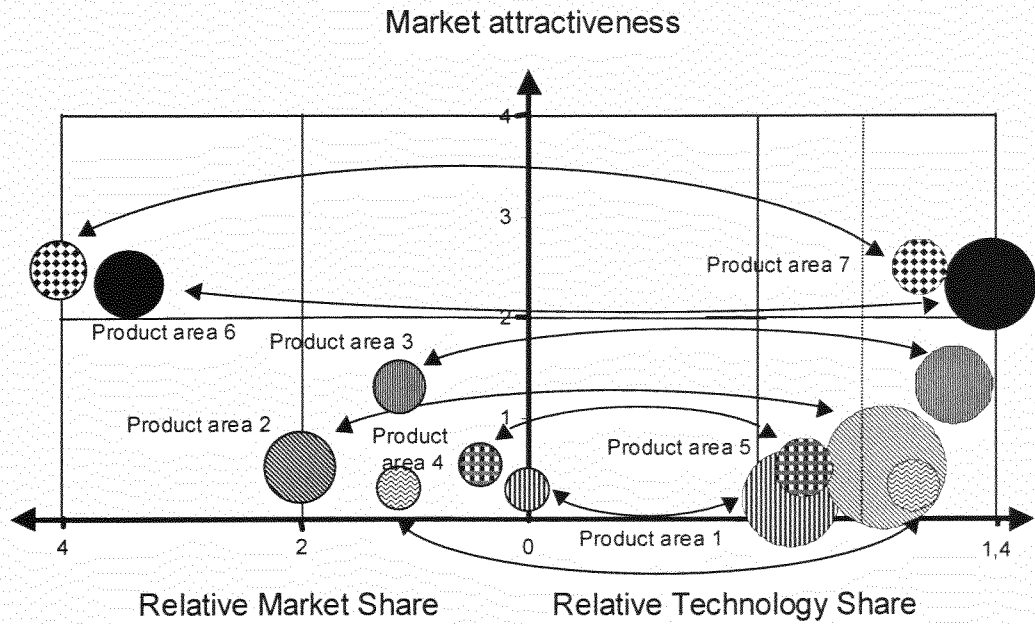
<b>II. Selected statistics (R<sup>2</sup> = 0.7)</b>	Regression Coefficient	Standard Error	Significance
Patents granted	0.24	0.47	n.s.
International Scope	1.83	0.79	0.02
Citations	1.90	0.73	0.00

### 3.2 Results of the Portfolio Analyses

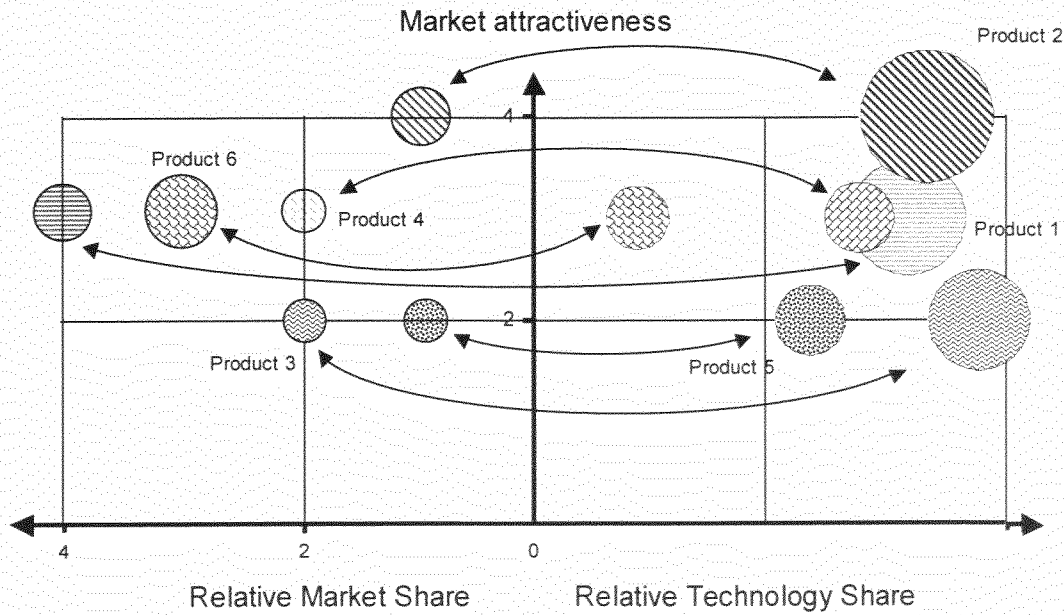
Based on this raw data we constructed multiple portfolio visualisations on the business unit level and on the level of product fields. Please refer to figure 5 and figure 6 for sample portfolios on the product area and the business unit level. The portfolios were discussed in a joint meeting with marketing, R&D and patent managers from the company. Some of the discussion helps to better understand and interpret the portfolios.

The analysis on the product area level (figure 5) draws a picture of a very attractive area, i.e., each product growing at least as fast as the business unit. In most cases, the products are positioned in corresponding quadrants of the portfolio. Thus, R&D and Marketing strategies are well aligned in these product areas.

In some cases, however, there are obvious differences. Product 2 has the second highest value for technology share, but an insufficient market share. In addition, it has the highest number of patent applications in this product area. In our discussions with company executives, intense competitive pressure was identified as the main explanation for the weak market share of product 2. The market is largely dominated by a strong competitor. The massive R&D investments are necessary to defend the company's market position and to be able to participate in a market driven by technology. The outcome of the analysis was the decision to develop a marketing case containing strategies how to increase market share.



**Figure 5** The integrated portfolio: An application for a product area with six products (disguised)



**Figure 6** The integrated portfolio: An application for a business unit with seven product areas (disguised)



Product 6 enjoys a strong market position in a high growth market. In contrast, its technology position is fairly weak. This disparate positioning could be attributed to the fact that the company was still in the process of reinforcing its technological position and thus still intended to file for more patents. The need for further R&D investment in this product is clearly highlighted by the portfolio analysis and will be further emphasized by the company.

Product 3 is characterized by a strong technological position and average numbers for market share and market growth. The company under consideration has a strong R&D emphasis on this product, however, the contribution to sales is rather modest. The discussion revealed that Marketing and R&D perceive the potential of the recently introduced product quite differently. It was decided to conduct a workshop with multiple company experts in order to reassess the attractiveness of this product. Based on the outcome a decision ought to be made whether R&D investments in this product should be realigned.

Figure 6 depicts the portfolio analysis on the business unit level. Two of the product areas (6 and 7) enjoy high growth rates and strong technological and market positions. These were considered the most important product areas in the short and mid term. Thus, the generic strategic recommendation to reinforce the positionings with significant expenditures was adequate. Product area 2 is the "cash cow" of the company which is clearly indicated by the portfolio. Some R&D is further spend on the corresponding technology in order to maintain the present position. R&D and Marketing strategies are aligned in these product areas as proposed by management theory.

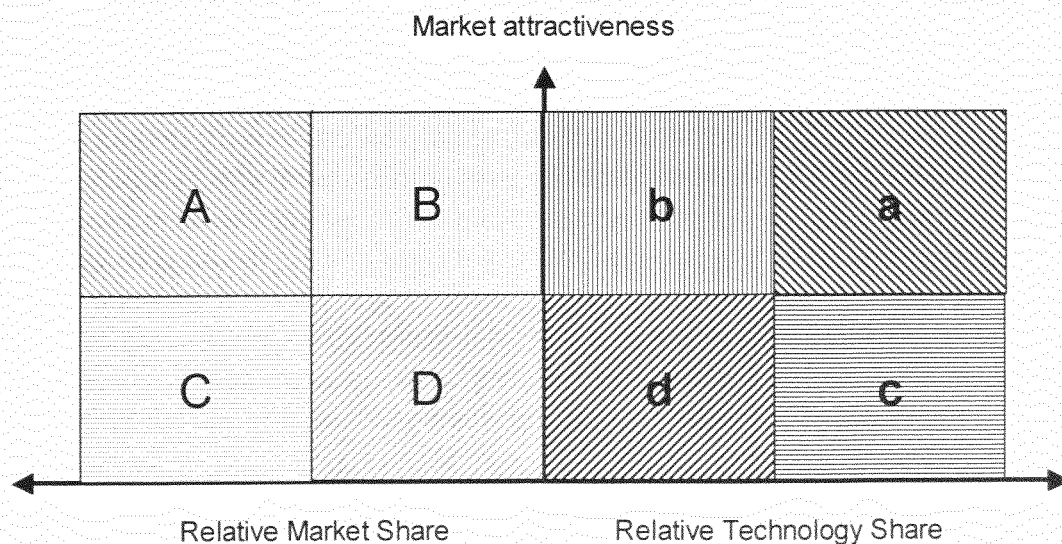
In contrast, market and technology positions in product areas 1,3,4 and 5 show less consistency. Whereas less R&D emphasis is put on product areas 4 and 5 as a result of lower than expected market growth, the high R&D emphasis on product areas 1 and 3 is disturbing. This result led to a long discussion among company managers about the underlying reasons. For one case the discussion revealed that the market for this class of substances had collapsed a while ago due to a decrease in environmental awareness. The company had expected a tightening of environmental legislative regulations which failed to materialise. Even after this event, R&D resources were still allocated to this area, although there are currently no prospects of a change of market conditions in the near future. R&D and marketing managers agreed to take a closer look into this case and potentially stop all projects in this field.

In sum, the integrated portfolio analyses have shown that market and technology positions in the company under consideration are not always aligned. These results have led to a first discussion among company managers on the root causes for the observed inconsistency of portfolio positions. This already highlights the need for intensive discussion based on the portfolio presentations before final conclusions are made. All managers perceived this to be very helpful to gain a common understanding of Marketing and R&D strategies. To get a more details picture and in order to incorporate further knowledgeable experts and decisions makers in the company it

was decided to carefully review the marketing, patenting and R&D strategies for some of the concerned areas.

#### 4 Conclusions

The integrated portfolio can be a powerful tool for strategic planning purposes because it offers an efficient and effective way to better align Marketing and R&D strategies. The integrated portfolio combines a widely known and used market portfolio concept with a patent portfolio capturing the technological aspects. Both approaches can fully exploit their respective strengths when objective data can be used. Both portfolios' dimensions, esp. the abscissa, have been shown to impact business performance, thus making the portfolio illustrations especially meaningful for decision makers in firms. The clear focus on market orientation in the integrated portfolio as expressed on the ordinate where the integration of both portfolios is achieved by using the market portfolio's initial dimension "market attractiveness". It is believed that a technology's attractiveness has to finally show on the market and that R&D strategies ought to be consequently aligned with market requirements (see section 1). In cases where market data is not yet available for new and future products, one should rely on accurate market forecasts derived from market research or other sources. The integrated portfolios can then not only be used as a tool to reassess current Marketing and R&D strategies, but also as an instrument for planning and monitoring existing new product development efforts. This task is an important challenge to new product management because the strategic assessment, selection and termination of new product development projects is a critical success factor [5,6]. Figure 7 summarizes the strategic implications which can be derived from the integrated portfolio.



**Figure 7** Overview about partial generic strategies in the integrated portfolio. Fields with the same letter share similar partial generic strategies in the market and technology part.

If both technology and products are placed in the same field of the market and technology portfolios represented by the combinations Aa, Bb, Cc and Dd in figure 7, the generic strategies from the separate portfolios can simply be added up and remain valid. The main advantage of our portfolio concept is the detection of separate positioning. In the case example, we elaborated on the combinations Ab, Ba, Cd and Dc. In these cases, different generic strategies have to be applied and those from the separate portfolios might become invalid as demonstrated by our case example. Several hypotheses can explain the differences and we tried to find case evidence in expert discussions. For a disparate positionings in the upper half of the portfolio, i.e. a high growth environment, a likely explanation for a strong technological position but weak market position would be an insufficient satisfaction of market needs. In this case, R&D expenditure should be cut back as it cannot be earned back in the future. In contrast, it could also be possible that the weak market position is due to strong competition in the product market. This would call for larger investments in marketing, R&D investments simultaneously held constant or scaled up. In a low growth environment, our hypothesis explaining a differing position would be a misappropriation of R&D investments. As market "cash cows" usually require massive economies of scale to be profitable, aggressively building market share would be a loss-making strategy. The sustainability of a market "cash cow" could also be threatened by a weak technological position. However, this need not be the case: if there are high barriers to entry due to economies of scale, the company does not need to protect its competitive position by property rights any more to prevent new firms from entering the market. We provided first evidence for possible strategic actions which might be applied in these situations.

Another strength of the portfolio method is the visualisation of complex decision problems. It lays the ground for an intensive discussion of portfolio positions, their root causes and their implications. The case example clearly shows that the integrated portfolio establishes a framework for joint strategy discussions between technical and non-technical functions like R&D, Marketing and the Patent Department. As it is known from tools like quality function deployment [16], which is used in the design phase of new product development, the integrated portfolio can lead to more and structured cross-functional communication in the strategic planning process, thus reducing interfaces and assuring that Marketing and R&D strategies are aligned on the strategic level. Managers from the company stressed that the discussion focused on the content of the portfolios rather on the assumptions made to draw the portfolios as it was experienced in the past with other portfolios. This is mainly attributed to the use of objective patent data for the technology portfolios.

Another important benefit of the integrated concept is that further knowledge is created during the development and the implementation phase. The systematic condensation of patent data and the simultaneous visualisation of technology and products create a significant amount of knowledge. With the help of the integrated approach, it becomes possible to understand an individual product's technological and market positions and their interrelatedness. The analyses create a significant amount

of important knowledge which separate portfolio analyses cannot provide. This was clearly demonstrated in the case example and expressed by the managers of the firm which had been involved in the process.

The limitations of this work can be mainly attributed to the case study approach which is in a first step justified when new concepts are developed and preliminary tested. In a next step we suggest that further large-scale research should be undertaken in that field with a focus on three central elements. First, further evidence is needed with respect to the measures of patent quality and their respective weights. Second, the relationship between positions in the integrated portfolio and company performance could explicitly be tested. Thirdly, a study could investigate if management in companies using this type of integrated portfolio makes indeed better decisions with respect to aligning R&D strategies with market requirements.

## References

- 1 Narver, J.C. and Slater, S.F. (1990) 'The Effect of Market Orientation on Business Profitability', *Journal of Marketing*, Vol. 54, pp. 20-35.
- 2 Blundell, R., Griffith, R. and v. Reenen, J. (1999) 'Market Share, Market Value and Innovation in a Panel of British Manufacturing Firms', *Review of Economic Studies*, Vol. 66, pp. 529-554.
- 3 Capon, N., Farley, J.U. and Hoenig, S. (1990) 'Determinants of Financial Performance: A Meta-Analysis', *Management Science*, Vol. 36, pp. 1143-1159.
- 4 Chaney, P.K. and Devinney, T.M. (1992) 'New Product Innovations and Stock Price Performance', *Journal of Business, Finance and Accounting*, Vol. 19, pp. 677-695.
- 5 Cooper, R.G. and Kleinschmidt, E.J. (1995) 'Benchmarking the Firm's Critical Success Factors in New Product Development', *Journal of Product Innovation Management*, Vol. 12, pp. 374-391.
- 6 Ernst, H. (2002) 'Success Factors of New Product Development: A Review of the Empirical Literature', *International Journal of Management Reviews*, Vol. 4, pp. 1-40.
- 7 Souder, W.E., Buisson, D. and Garrett, T. (1997) 'Success Through Customer-Driven New Product Development: A Comparison of U.S. and New Zealand Small Entrepreneurial High Technology Firms', *Journal of Product Innovation Management*, Vol. 14, pp. 459-472.
- 8 Christensen, C. M. (1997) *The Innovator's Dilemma: When new technologies cause great firms to fail*, Boston: Harvard Business School Press.
- 9 Porter, M. E. (1983) *Competitive strategy: techniques for analyzing industries and competitors*, New York: The Free Press.

- 10 Tushman, Michael L. and O'Reilly, Charles A. (1997) *Winning through innovation: a practical guide to leading organizational change and renewal*, Boston: Harvard Business School Press.
- 11 Bower, Joseph L. and Christensen C. M. (1995) 'Disruptive technologies: Catching the wave', *Harvard Business Review*, pp. 43-53.
- 12 Brockhoff, K. (1999), *Forschung und Entwicklung. Planung und Kontrolle*, 5th edition, München: Oldenbourg.
- 13 Ernst, H. (1997) 'The use of patent data for technological forecasting: The diffusion of CNC-technology in the machine tool industry', *Small Business Economics*, Vol. 9, pp.225-240.
- 14 Lange, V. (1994) *Technologische Konkurrenzanalyse*, Wiesbaden: Gabler Verlag.
- 15 Holland, S., Gaston, K., Gomes, J. (2000), 'Critical success factors for cross-functional teamwork in new product development', *International Journal of Management Reviews*, Vol. 2, pp. 231-260
- 16 Griffin, A. und Hauser, J.R. (1992) 'Patterns of Communication Among Marketing, Engineering, and Manufacturing – A Comparison between two Product Teams', *Management Science*, Vol. 38, pp. 360-373.
- 17 Brockhoff, K. (1989) *Schnittstellen-Management. Abstimmungsprobleme zwischen Forschung und Entwicklung und Marketing*. Stuttgart: Schäffer-Poeschel.
- 18 Kahn, K.B. (1996) 'Interdepartmental Integration: A Definition with Implications for Product Development Performance', *Journal of Product Innovation Management*, Vol. 13, pp. 137-151.
- 19 Souder, W. E. (1987), *Managing new product innovations*, Lexington: Lexington Books.
- 20 Cooper, R.G. (1984) 'The Strategy-Performance Link in Product Innovation', *R&D Management*, Vol. 14, pp. 247-259.
- 21 Griffin, A. and Hauser, J.R. (1996), 'Integrating R&D and Marketing: A Review and Analysis of the Literature', *Journal of Product Innovation Management*, Vol. 13, pp. 191-215.
- 22 Wolfrum B. (1991) *Strategisches Technologiemanagement*, Wiesbaden: Gabler Verlag
- 23 Möhrle, M. and Voigt, I. (1992) 'Das FuE-Programm-Portfolio in praktischer Erprobung', *Zeitschrift für Betriebswirtschaft*, Vol. 63, pp. 973-992.
- 24 Day, G. S. (1977) 'Diagnosing the Product Portfolio', *Journal of Marketing*, Vol. 41, pp. 29-38.
- 25 Hedley, B. (1977) 'Strategy and the "Business Portfolio"', *Long Range Planning*, Vol. 10, pp. 9-15.
- 26 Wind, Y. (1982) *Product Policy: Concepts, Methods and Strategy*, London: Addison-Wesley Publishing, pp. 107-148.

- 27 Hambrick, D.C, MacMillan, I. C. and Day D.L. (1982) ' The Product Portfolio and Profitability – A PIMS-Based Analysis of Industrial-Product Businesses, *Academy of Management Journal*, Vol. 25, pp. 733-755.
- 28 Hambrick, D.C, MacMillan, I. C. and Day D.L. (1982) ' Strategic Attributes and Performance in the BCG Matrix – A PIMS-Based Analysis of Industrial Product Businesses, *Academy of Management Journal*, Vol. 25, pp. 510-531.
- 29 Buzzell, R.D. and Gale, B.T. (1987) *The PIMS Principles*, New York: The Free Press.
- 30 Schoeffler, S., Buzzell R.D. and Heany D.F. (1974) 'Impact of strategic planning on profit performance', *Harvard Business Review*, Vol. 52, pp. 137-145.
- 31 Polli, R. and Cook V. (1969) 'Validity of the Product Life Cycle', *Journal of Business*, Vol. 42, pp. 385-401.
- 32 Homburg, C. (1998) *Quantitative Betriebswirtschaftslehre*, Wiesbaden: Gabler Verlag.
- 33 Wind, Y. and Mahajan, V. (1981) 'Designing product and business portfolios', *Harvard Business Review*, Vol. 59, pp. 155-165.
- 34 Wind, Y., Mahajan, V. and Swire D.J. (1983) 'An Empirical Comparison of Standardized Portfolio Models', *Journal of Marketing*, Vol. 47, pp. 89-99.
- 35 Ernst, H. (1999) 'Evaluation of dynamic technological developments by means of patent data', in Brockhoff, K., Chakrabarti, A.K. and Hauschildt, J. (Eds.), *The Dynamics of Innovation*, Berlin: Springer, pp. 103-132.
- 36 Ernst, H. and Teichert T. (1998) 'The R&D/Marketing interface and single informant bias in NPD research: An illustration of a benchmarking case study, *Technovation*, Vol. 18, pp. 721-739.
- 37 Griliches, Z. (1990) 'Patent Statistics as Economic Indicator', *Journal of Economic Literature*, Vol. 28, pp. 1661-1707.
- 38 Brockhoff, K. (1992) 'Instruments for patent data analyses in business firms', *Technovation*, Vol. 12, pp. 41-58.
- 39 Ernst, H. (1998) 'Patent Portfolios for strategic R&D planning', *Journal of Engineering and Technology Management*, Vol. 15, pp. 279-308.
- 40 Brockhoff, K. and Chakrabarti, A. (1997) 'Take a Proactive Approach to Negotiating your R&D Budget', *Research Technology Management*, Vol. 40, pp. 37-41
- 41 Austin, D.H. (1993) 'An event-study approach to measuring innovative output: The case of biotechnology', *American Economic Review*, Vol. 83, pp. 253-258.
- 42 Deng, Z., Lev, B. and Narin F. (1999) 'Science & Technology as Predictors of Stock Performance', *Financial Analysts Journal*, Vol. 55, S. 20-32.
- 43 Ernst, H. (2001) 'Patent Applications and Subsequent Changes of Performance: Evidence from Time-Series Cross-Section Analyses on the Firm Level', *Research Policy*, Vol. 30, pp. 143-157.

- 44 Shane, S. (2001) 'Technological opportunities and new firm creation', *Management Science*, Vol. 47, pp. 205-220.
- 45 Ernst, H. (1996) *Patentinformationen für die strategische Planung von Forschung und Entwicklung*, Wiesbaden: Deutscher Universitätsverlag.
- 46 Basberg, B. L. (1987) Patents and the measurement of technological change: A survey of the literature, *Research Policy*, Vol. 12, pp. 131-141.
- 47 Albert, M.B., Avery, D., Narin, F. and McAllister, P. (1991) 'Direct validation of citation counts as indicators of industrially important patents', *Research Policy*, Vol. 20, pp. 251-259.
- 48 Carpenter, M.P., Narin, F. and Woolf, P. (1981) 'Citation rates to technologically important patents', *World Patent Information*, Vol. 3, pp. 160-163.
- 49 Harhoff, D., Narin, F., Scherer, F.M. and Vopel, K. (1999) 'Citation frequency and the value of patented innovations', *Review of Economics and Statistics*, Vol. 81, pp. 511-515.
- 50 Narin, F., Noma, E. and Perry, R. (1987) 'Patents as indicators of corporate technological strength', *Research Policy*, Vol. 16, pp. 143-155.
- 51 Achilladelis, B (1993) 'The dynamics of technological innovation: The sector of antibacterial medicines', *Research Policy*, Vol. 20, pp. 251-259.
- 52 Frohman, A.L. and Bitondo D. (1981) 'Coordinating Business Strategy and Business Planning', *Long Range Planning*, Vol. 14, pp. 58-67.
- 53 Capon, N. and Glazer, N. (1987) 'Marketing and Technology: A Strategic Coalignment', *Journal of Marketing*, Vol. 51, pp. 1-14.
- 54 Devinney T. M. and Stewart D. W. (1988) 'Rethinking the Product Portfolio: A Generalized Investment Model', *Management Science*, Vol. 34, No. 9, S. 1080-1095.
- 55 Albers, S. and Krafft, M. (2000) 'Regeln zur fast-optimalen Bestimmung des Angebotsaufwands', *Zeitschrift für Betriebswirtschaft*, Vol. 70, pp. 1083-1107.
- 56 Wind Y. and Saaty T. L. (1980) 'Marketing Applications of the Analytical Hierarchy Process', *Management Science*, Vol. 26, pp. 641-658.
- 57 Schlegelmilch, G. (1999) *Management strategischer Innovationsfelder*, Wiesbaden: Gabler Verlag.

**Forschungspapiere  
der Wissenschaftlichen Hochschule für Unternehmensführung  
(WHU)**

**- Otto-Beisheim-Hochschule -**

Lfd. Nr.	Autor	Titel
1. (1991)		Diese Forschungspapiere sind nicht mehr einzeln aufgeführt. Sollten Sie daran interessiert sein, wenden Sie sich bitte an das Rektorat der WHU (Tel. 0261-6509151)
60. (1998)		
61.	Weber, Jürgen	Stand und Entwicklungsperspektiven des Logistik-Controlling (Januar 1999)
62.	Weber, Jürgen Schäffer, Utz	Entwicklung von Kennzahlensystemen (Februar 1999)
63.	Hommel, Ulrich Riemer-Hommel, Petra	Die ökonomische Bewertung von Arbeitsflexibilisierungsmaßnahmen mit Hilfe des Realoptionsansatzes (April 1999)
64.	Dufey, Günter	"Asian Financials Markets – A Pedagogic Note" (forthcoming in "Journal of Asian Business, Vol. 15, no.1, 1999) (Mai 1999)
65.	Weber, Jürgen Schäffer, Utz Hoffmann, Dirk Kehrmann, Titus	Technology Assessment zur Sicherstellung einer rationalen Technologiepolitik (Juni 1999)
66.	Weber, Jürgen Schäffer, Utz	Auf dem Weg zu einem aktiven Kennzahlenmanagement (Juni 1999)
66 (E).	Weber, Jürgen Schäffer, Utz	On the Way to Active Management of Performance Measures (June 1999, translated October 1999)
67.	Weber, Jürgen Schäffer, Utz Hoffmann, Dirk Kehrmann, Titus	Koordination technikreflektierender Forschung in Deutschland – eine Analyse (Juni 1999)



<b>Lfd. Nr.</b>	<b>Autor</b>	<b>Titel</b>
68.	Schäffer, Utz	Zeit des Managements – Kern einer Theorie der Unternehmenssteuerung? (August 1999)
69.	Weber, Jürgen Brettel, Malte	Management des Praxisbezugs der Lehre an der WHU Koblenz – Konzept und Erfahrungen (August 1999)
70.	Weber, Jürgen Schäffer, Utz Langenbach, Wilm	Gedanken zur Rationalitätskonzeption des Controlling (Oktober 1999)
71.	Weber, Jürgen Schäffer, Utz	Controlling als Koordinationsfunktion? – Zehn Jahre nach Küpper/Weber/Zünd (Oktober 1999)
72.	Weißenberger, Barbara Stromann, Hilke	Die Bedeutung von Prozeßkosten für die Bewertung der Herstellungskosten nach §255 Abs. 2 HGB (Dezember 1999)
73.	Weber, Jürgen Brettel, Malte Jaugey, Cyril Rost, Cornelius	Business Angels in Deutschland – Wie Business Angels in Deutschland jungen Unternehmern helfen (Februar 2000)
73 (E).	Weber, Jürgen Brettel, Malte Jaugey, Cyril Rost, Cornelius	Business Angels in Germany – How Business Angels in Germany help new entrepreneurs (February 2000)
74.	Weber, Jürgen Schäffer, Utz Prenzler, Carsten	Charakterisierung und Entwicklung von Controlleraufgaben (Juli 2000)
75.	Schäffer, Utz	Kontrollieren Controller? – und wenn ja: Sollten sie es tun? (August 2000)
76. (E)	Dufey, Günter	The Blurring Borders of Banking (August 2000)
77.	Weber, Jürgen	Neue Perspektiven des Controlling (September 2000)
78.	Weber, Jürgen Dehler, Markus	Erfolgswirkungen einer logistischen Führungskonzeption (April 2001)

79. Weber, Jürgen  
Dehler, Markus      Der Einfluss der Logistik auf den Unternehmenserfolg (April 2001)
80. (E) Trautwein, Andreas  
Vorstius, Sven      Internet Hype and the Quest for Value-Relevance – An empirical investigation of value-drivers on the Neuer Markt - (Juni 2001)
81. Brettel, Malte  
Thust, Solveig  
Witt, Peter      Die Beziehung zwischen VC-Gesellschaften und Start-Up-Unternehmen (September 2001)
82. Brettel, Malte      Entscheidungskriterien von Venture Capitalists (September 2001)
83. Witt, Peter  
Brachtendorf, German      Gründungsfinanzierung durch Großunternehmen
84. Brettel, Malte      Deutsche Business Angels im internationalen Vergleich  
*Empirische Erkenntnisse* (November 2001)
85. Witt, Peter  
Zillmer, Peter      Renditeorientierte Business Inkubatoren in Deutschland – eine empirische Analyse von Marktveränderungen
86. (E) Ernst, Holger  
Soll, Jan Henrik      “An integrated portfolio approach to support market-oriented R&D planning”
87. van der Velden, Claus  
Zillmer, Peter      Corporate Raider – Möglichkeiten und Grenzen im deutschen Governance System

Rektorat / April 2002