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Understanding the »Market-Pull«: Accelerating the Exploitation of Manufacturing Technologies

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ABSTRACT

The identification and assessment of potential technology exploitation opportunities presents companies with several problems. From a practical point of view, there is an almost unmanageable large amount of potential sales markets and market segments, in which for instance a given manufacturing technology could be exploited. Yet, the "market pull" remains unclear: the characteristics of the market segments (its dynamic, lifecycle, High-Tech/ Low-Tech, etc.) do not provide companies with direct information on whether the manufacturing technology at hand is able to meet the requirements of these markets at all. From a scientific point of view, no link between market characteristics ("market pull") and technological performance parameters of manufacturing technologies ("technology push") has been established yet. This paper proposes an approach of such an assignment of technical performance parameters to market characteristics, that would allow an automated pre-selection of potential sales markets, reduction of the search scope and thus a significant acceleration of the exploitation process.

Keywords: technology push, market pull, technology leveraging, diversification, technology exploitation, new business opportunities

INTRODUCTION AND MOTIVATION

Technology-oriented companies are facing challenging questions: How can the momentum of generating innovative technological solutions be maintained, while being confronted with cost-cutting projects at the same time? How can the customers of the existing markets be served, yet at the same time other market segments be successfully conquered? These questions show that the relevance of a structured management of technologies in companies is of great importance [34].

A consortium study by the Fraunhofer Institute for Production Technology (Fraunhofer IPT) in 2012 showed that companies have not yet established a systematic search for external exploitation options. Overall, only about 25% of the companies surveyed are actively looking for new possible areas of application. One reason for the lack of systematic technology exploitation is the high complexity of the task (i.e. a nearly unmanageable large amount of potential sales markets, in which the production technology of a machine tool manufacturer could be used, exists). The limited availability of human and financial resources tends to result in the fact that tasks of technology management are carried out by employees of R&D or production in parallel with their tasks of daily business [16]. Furthermore, these employees often lack explicit methodical knowledge and strategic vision besides time for comprehensive projects to identify contra intuitive possibilities for the exploitation of manufacturing technologies. Thus the resulting exploitation of technologies often takes place too close to already existing markets.

This paper further explains the depicted problem and outlines an idea for a methodological approach, that intends to

a) significantly speed up the exploitation process,

b) reducing the risk of missing easily includable exploitation opportunities, and

c) efficiently allocate resources (by investigating only potentially attractive market segments).

The large number of market segments under consideration can probably be reduced by a semi-automated preselection. A company would profit in the following way: Many market segments, which a manufacturing technology cannot serve (due to physical limitations) can be excluded from any further investigation. Thus, the analytical framework will be reduced effectively. A detailed consideration in the form of an assessment of the economic attractiveness of the remaining market segments can take place afterwards.

If a potentially attractive market segment is identified, exploitation opportunities can be located and specified.

Addressees of the presented article are manufacturers of manufacturing technologies (equipment manufacturers), companies that use manufacturing technologies (e.g. job shops) as well as researchers and companies in the field of manufacturing technology research with a diversification intention.

STATE OF THE ART

Technology Assessment

Opitz presented the "Opitz key" in 1970 and provided a universal classification system for manufacturing technologies [28]. The classification system is based on product properties. In the broadest sense the Opitz key systemizes the basic technology performance parameters. Based on this fundament, Group Technology emerged. As Schuh et al. mention [34], it utilizes the similarities of products or product components and combines them to meaningful modules and many current and older projects rely on components of this concept [1][9][10][20]. Zahn et al. aim to identify competition-related technology areas as well as benchmarking the company-specific situation. Therefore they propose to link market information with the technical features of a technology. However, this link is only possible if companies are able to functionally describe their own technology. Zahn et al. propose a systematic approach and the creation of a functional profile, which is intended to function as a link between market and technology [37]. However, the authors' remarks remain abstract and no universally valid model to develop a functional profile is provided.

Market Segmentation

Already in 1951 Dean [8] coined the concept of market segmentation and stressed the importance to differentiate the overall market into segments that can be structured along e.g. a geographic, demographic or psychographic dimension [5][12][14][24][27]. By establishing dedicated criteria, an elaboration of both relevant and prioritized submarkets along the given products, processes or technologies can be carried out [22].

The operational practicability of a targeted marketing of technologies is enabled by procedural aspects with the aim of a systematically and methodically derived segmentation result [7]. The easiest way to do so is a one-dimensional segmentation based on individual criteria, which focus only certain aspects of organizational behavior procurement (e.g. type of organization or purchasing risk) [25]. In addition to the two-stage segmentation method according to Wind and Cardozo [36] there do exist three-stage processes [17][32]. The two- or three-stage approaches by Wind and Cardozo or Scheuch have the following in common: Both make a distinction by environmental and organizational characteristics (e.g. location or political condition) within the first stage. Within the second stage, intra-organizational characteristics (e.g. organizational structures or restrictions) are utilized. At the third stage they differentiate between individual characteristics of the members of the segment. The systematic segmentation of a heterogeneous meta-market into homogeneous sub-markets is of strategic importance for companies as it allows an identification of competitive advantages and can be carried out by a maximum overlap of offered (technological) performance and customer expectations. Despite the strategic importance, technology-based segmentation methods cannot be found in the current literature [7].

Market Evaluation

Evaluating the attractiveness of markets is closely linked to market segmentation. Market evaluation has been intensively discussed in research and corporate practice [26][29][30]. As a pioneer of market analysis Porter [29] described in 1985 that the attractiveness of a segment mainly depends on its inherent structural attractiveness, existing market barriers, its size and growth as well as the degree of overlap between company-specific skills and the segment given needs [6]. Determinants of the structural appeal are the five dimensions of the classic "Five Forces Model". According to this model the assessment of the following five criteria is central for determining the market attractiveness: (1) the competition between competitors within the segment, (2) the threat of potential entry of competitors, (3) potential substitutes, (4) the bargaining power of customers and (5) the bargaining power of suppliers [29].

In the literature a wide range of potential dimensions with the attempt of assessing market attractiveness can be found. In addition to the already highlighted importance of market size and market growth, other parameters, particularly in terms of market quality, can be identified. Among them there is i.e. the profitability of the industry, the position within the product life cycle, the price sensitivity, the required technological know-how, the investment intensity or the variability of the competition [19]. Yet there is a scientific shortcoming in the technology-oriented assessment of markets. However, for an economic assessment of market segments an extensive preparatory work exists.

Interim Conclusion of the Preliminary Research

Even though a variety of successful research projects has been conducted concerning technology assessment, market segmentation and market evaluation, the preliminary work remains abstract, thus being not easily convertible for companies.

This lack of a systematic approach becomes especially apparent when diversification projects are being conducted. At the Fraunhofer IPT in the department "Technology Management", many diversification projects have been conducted and the experience shows that, due to a lack of "standard process for technology exploitation", the result of a diversification project it heavily dependent on the consultant being responsible for the analysis. Two consultants, even if they share the same experience, will most likely not identify the same applications for a technology that needs to be exploited. This is due to the current process in use, which relies more on inventive ideas of the consultant rather than on a systematically approach and leads to a non-reproducibility of the process.

From this fact arises the need for a generic however intuitively applicable method to match technology performance parameters ("technology push") with existing market needs ("market pull").

PROBLEM DESCRIPTION AND POSSIBLE SOLUTION APPROACHES

Particular product technologies are characterized by a very large heterogeneity regarding their properties (e.g. pencil vs. smartphone) and a generic description of product technologies is very complex. That is why exclusively manufacturing technologies are considered, while material and product technologies are specifically excluded from consideration.

This paper states two underlying hypotheses:

1) The basic principle of a manufacturing technology has cross-sector exploitation potential. A five-axis milling-machine for instance is being used in a variety of different branches (automotive, aerospace, tooling segment, Oil & Gas, …), since it enables the realization of certain product properties which are branch-trespassing (e.g. high surface quality, complex and 3D shapes, large cutting volumes). Solely the context and use-case can differ drastically, e.g. from being used in a small batch production up to a mass production.

2) The second assumption states that certain performance parameters (e.g. regarding feasible dimensions, production volumes, achievable surface qualities or tolerances of a manufactured product) of manufacturing technologies directly influence in which market segments the

technology at hand can potentially be utilized. An Additive-Manufacturing technology like Selective-Laser Melting (SLM) for instance is particularly usable for complex products with the lot size 1 yet improper for the repetitive mass production of simple products.

Since no scientific approach to compare and align market and technology characteristics could be identified in the preliminary research, this paper presents an initial framework to understand the problem of fast and efficient technology exploitation, independent from the choice of the underlying manufacturing technology. Concerning this topic, the aim of further research should be the development of a sound, scientific "translation" of technology performance parameters into specific market characteristics in order to enable a direct comparison and thus a selection of distinct segments to focus resources on. Figure 1 shows a potential framework for further research to compare and align market and technology characteristics.

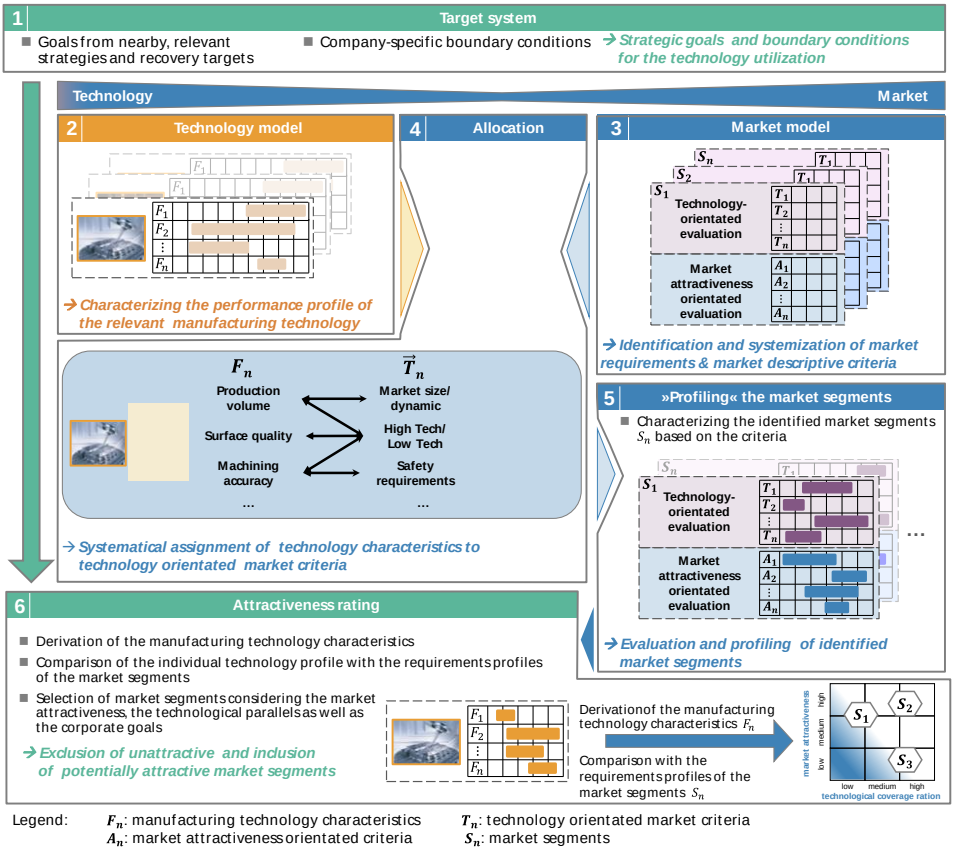

Figure1. *Potential framework (how to match technology-push and market-pull)*

Description of the Potential Framework

At first, a suitable model for company-specific characterization in the form of a target system needs to be developed. For this purpose, company characteristics such as available financial and human resources, the intended planning horizon or innovation orientation as well as the technology strategy should be analyzed. Those company characteristics are likely to influence the choices of technology exploitation and thus constitute the framework of technology exploitation. Subsequently, specific exploitation targets should be derived, which - in conjunction with the framework - can later be the guidelines for the technology exploitation and evaluation of markets.

Furthermore, a generic description of manufacturing technologies has to be provided. At this point, the technology model of Graw can be utilized, which covers all relevant parameters of a manufacturing technology. Furthermore, the model allows a manufacturing technology-specific standardization of parameters, thus taking into account the great variability within the parameters between different production technologies. Using this model, it would be possible to describe the characteristics of the exploited manufacturing technology in form of a »performance profile«. The

characterization of the target markets could be realized by a market model, which systematizes the search for market segments related to manufacturing technologies and specifies the necessary information for further assessment. In addition, consistent market attractiveness oriented criteria have to be developed. They should describe the economic attractiveness of the compiled market segments.

In a further step the performance parameters of manufacturing technologies should be assigned to technology-oriented market criteria. As there currently is no appropriate scientific preparatory work, this step is vital for success. Having worked out how technological performance parameters and technology-oriented market criteria (market needs) can be linked, an assessment of the elaborated market segments could take place. Based on a technological and economical profiling of market segments, a final assessment of attractiveness can be carried out in the form of a »profile matching«.

The overall research objective should be the development of a method, which allows users to extensively exploit the potential of manufacturing technologies through a systematic, technology-oriented selection of target markets (a. significantly increase speed, b.) reduce risk of missing opportunities and c.) efficiently allocate resources).

Detailed Description of the Potential Framework

No. 1: Target System

At first, factors and conditions that have an influence on technology planning and exploitation have to be identified. The available financial and human resources as well as the prevailing culture of innovation of a company are for instance particularly crucial for technology planning and exploitation. Furthermore, there is a strong relationship between technology planning and technology strategy, as the strategy represents a long-term target image of technology planning and has significant influence on the latter [15]. That is why, in addition to resourcing and innovation focus, also corporate characteristics which influence technology strategic decisions have to be considered. The result of step 1 should be a set of relevant objectives, which would allow users to define a strategic positioning of technology exploitation on specific target markets for manufacturing technologies. The set of targets should be aligned with the company-specific conditions and technology strategy. Companies must be able to estimate the impact of these conditions and constraints on the choice of the exploitation option. The specific characteristics of the conditions (e.g. available resources or time restrictions) should be taken into consideration to estimate whether a market segment is potentially attractive. Therefore, methodological approaches like the morphological box and the "Analytic Hierarchy Process" should be considered [31][38].

No.2: Technology Model

In step 2 a way to comprehensively describe manufacturing technology in terms of relevant parameters and thus make them accessible for a purposive characterization should be examined. Schuh et al. mention, that already existing work and models for the characterization of technologies are distinguished by a high degree of heterogeneity [34]. The authors explain that this is due to the fact that they were developed in the context of specific requirements of various scientific disciplines, such as the complexity and variant management, quality management, innovation management or the construction technique [2][21][23][33]. Thereby addressed challenges cover a wide range, beginning at the increase in product quality, promoting cross-industry innovation, the identification of diversification options up to reducing the product and production complexity. The generic orientation logic for the challenges mentioned above varies between technology push and market pull approaches. In most cases it directly focuses on product improvement and not on the underlying manufacturing technologies. As mentioned above, the currently developed model for the characterization of manufacturing technologies by Schuh [34] offers an appropriate framework: It is application-oriented on the one hand, but covers all relevant characteristic performance parameters of a manufacturing technology on the other hand. Furthermore, the model allows a specific standardization of parameters for manufacturing technologies. This ensures the attention for the great variability within the parameters of different manufacturing technologies.

No.3: Market Model

The aim of step 3 would be the systematic identification of target markets and market segments, in which an exploitation of manufacturing technologies can take place. A methodology should be developed within the market model to segment and assess the attractiveness of market segments. The decisive factor would be the achievement of a targeted level of detail. In case of huge numbers of market segments and technology-oriented criteria the applicability of the methodology cannot be ensured.

In practice, the market demarcation has been established with the help of industry codes [13]. In Europe this differentiation is often made according to the NACE-code, whereas the United Nations uses the ISIC Code [11]. This preparatory work could be used to develop the market segments and criteria. As a methodological support the cluster analysis [4] and the similarity and distance analysis [18] could be helpful for detecting similar structures in the databases and demarcate market segments. Furthermore, the multivariate regression [4] could be used to develop correlation or dependency structures.

In addition to the already mentioned technology-oriented market criteria, also market attractiveness related criteria (e.g. existing barriers to market entry, market growth, market shares) need to be elaborated. These criteria are crucial to assess the economic attractiveness of market segments (independently of the underlying manufacturing technology being assessed).

Result of step 3 should be a market model that identifies potential markets in which manufacturing technologies can be used and provides criteria to generically describe these market segments. The criteria need to be transferred to the assignment model in step 4. The assessment of market segments based on the given criteria would finally take place in step 6.

No.4: Assignment Model

Step 4 would answer the main research question: Can market segments be described manufacturing-technology-oriented and thus be assessed concerning their exploitation potential for manufacturing technologies?

To answer the research question, research has to be done to elaborate which of the manufacturing technology criteria from step 2 address the technology-oriented market criteria from step 3. A n:n assignment is assumed, which means that each technology criterion can be described as a specific vector of market criteria. This in turn means that a characteristic of a manufacturing technology potentially addresses several requirements of markets. For example, a manufacturing technology which can produce components with a very high surface quality, in general can be successfully used in market segments which are characterized by high-tech and high security requirements. Manufacturing technologies such as the plastic injection molding process could rather be utilized on market segments which are characterized by technology-oriented market criteria like high production volumes (because it is a repetitive process) and low market dynamics (high costs for tools must be depreciated over high number of pieces).

The assignment of descriptive market criteria to either market attractiveness or technology-oriented market criteria will most likely be the greatest challenge of the research project due to correlations and a non-uniquely assignment. It should be carried out with the help of expert interviews and semi-structured interviews [35]. A questionnaire should list the identified market criteria and market segments on the one hand, and the developed criteria for describing manufacturing technologies on the other hand. The experts then should assign which criteria (market requirements) might be affected by which technology characteristic or performance parameters. In addition, the experts should retrospectively provide information about what kind of technologies have been successfully exploited for which market segments.

The questionnaires then could be analyzed using Pareto analysis and multivariate regressions [4] to obtain a validated assignment of the technology criteria to the relevant market criteria. For the survey the Fraunhofer IPT might use its wide network of enterprises in the field of mechanical engineering and machine tool manufacturing, which is particularly researching at issues relating to manufacturing technologies with experts from industry and research.

The result of step 4 would be a sound and systematically derived mapping of technology criteria and technology-oriented market criteria.

No.5: Profiling of Market Segments

Step 5 aims at developing profiles for each of the identified market segments. On the basis of the identified technology and market oriented criteria, a systematic review of the market segments could take place. For this evaluation, the different characteristics of the respective segments should be identified through extensive market and literature research. The result of the evaluation is not intended to be a single numeric value. It is rather aspired to develop a "corridor" (e.g. an assorted characteristic is described through a range of 20-35 on a scale from 1-100). In this corridor the expression of the relevant market criterion and hence the requirement for a manufacturing technology could be reflected. The corridors should be standardized on a certain scale to ensure comparability of the segments. As indicated above, a meaningful number of market segments needs to be identified to realize this step within the framework of a research project.

The results of step 5 are multidimensional requirement profiles of the identified market segments.

No.6: Attractiveness Rating

The last step should provide a systematic approach which selects one or more market segments for the exploitation of the manufacturing technology.

The selection would be conducted via comparison of the »technological performance« profile (step I) and the »requirement profile« of the market segments (step 5). Such a comparison would be possible, because the technology's performance parameters can be "translated" in market criteria using the result of step 4. The assessment of attractiveness comprises two different dimensions: 1) the "technological degree of overlap" of the manufacturing technology with the identified relevant market segment requirements and 2) a "market attractiveness assessment" which assesses the market segment per se according to economic criteria.

The "technological overlap rate" (dimension 1) describes to what extent the manufacturing technology meets the technical requirements of the market segment. It determines whether a technology with its specific performance profile is able to operate a certain market at all (necessary condition), and, if so, to what extent the requirements are met. [If there is no overlap between the requirement corridors of technology-oriented market criteria and the corresponding performance corridor of technology performance criterion, the manufacturing technology could most likely not be exploited in this market segment - at least with the current scope - and therefore would be eliminated from further consideration. This exclusion would enable a useful reduction of the scope of market segments. In case of overlapping corridors, dimension 1 describes to what extent a manufacturing technology needs to be adapted for a successful exploitation in the relevant market segment.

The second dimension is a market attractiveness assessment (dimension 2). It determines the economic attractiveness of a market segment for the company as a sufficient condition. Criteria such as market shares, barriers to entry or the predominant competition are reviewed here.

It seems expedient that the decisions, which of the previously identified, generally operable and classified segments are chosen for technology exploitation, remains at the companies' management.

Even though the decision process would be supported by presenting the portfolio, the final assessment heavily depends on the corporate strategy and the company's goals (step 1). An exploitation of a manufacturing technology in a rapidly growing market for example might justify a necessary

adaptation of the technology. Presuming the company is willing to make additional investments in the technology adaption, the market segment would be assessed as attractive in this specific case. If a technology in turn should be exploited with minimal adjustments and with little or even no investment, market segments with a particularly high technological overlap rate are more attractive. These examples show that strategic guidelines might lead to a different willingness to invest, thus influencing the final assessment.

CONCLUSION AND OUTLOOK

Companies are in need of methodically support on improving and accelerating their technology exploitation process. The authors have found that the success of diversification projects is often determined by the creative potential of employees or consultants being responsible for the diversification process. In order to systematize and automate this process in the long run, the solution approaches mentioned above should be transformed into concrete research projects. This has also been confirmed by some of the Senior Consultants at Fraunhofer IPT, who believe that above explained method would be a plausible way to systematize the process. It is also planned to test the validity of this theory in an upcoming consultancy project at Fraunhofer IPT in Aachen.

The aim of the solution approach presented is not the identification of an explicit exploitation option for a manufacturing process. It is rather trying to raise awareness for the lack of a systematic, efficient solution for reducing the variety of exploitation options via a semi-automatic preselection. The emerging result of future research might be a list of a few relevant market segments for an exploitation of the technology at hand. In these market segments, the probability of finding a suitable application will be particularly high.

Overall the new process will not be solely dependent on individuals, steps will be traceable and the process will therefore be reproducible. This leads to a broader utility of the process as well as higher efficiency in the exploitation process.

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