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Development of Industry Sector Specific Factory Standards

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***Abstract*—**Due to shortening product and technology lifecycles, many companies use standardization approaches in product development and factory planning to reduce costs and time to market. Unlike large companies, where modular systems are already widely used, small and medium-sized companies often show a much lower degree of standardization due to lower scale effects and missing capacities for the development of these standards. To overcome these challenges, the development of industry sector specific standards in cooperations or by third parties is an interesting approach. This paper analyzes which branches that are mainly dominated by small or medium-sized companies might be especially interesting for the development of factory standards using the example of the German industry. For this, a key performance indicator based approach was developed that will be presented in detail with its specific results for the German industry structure.

***Keywords*—**Factory planning, factory standards, industry sector specific standardization, production planning.

I. Introduction

THE environment of producing companies is characterized by an increasing complexity and higher economic dynamics [1]. Main reason for this development is the globalization with a faster distribution of knowledge and technologies [2]. These circumstances mean huge challenges for all company functions and areas like product development, purchasing, production, or sales [3].

Looking at the production, shortening product and technology lifecycles [4] especially call for a higher adaptability of factory structures, which is achieved by more complex technical solutions. With a growing product variety, the complexity of production processes is increased additionally [5], which results in higher planning and operating costs of the factory. Considering the increasing cost pressure on globalized markets, this leads to the big challenge for producing companies to reduce their operating costs as well in early planning phases as in later series production. Overall, the "return on engineering" has to be maximized [6].

At the same time, factories should be built in continuously shorter time frames to satisfy customers´ demands in a time to market as little as possible. Current studies show that these challenges cause big deficits in the achievement of defined targets in factory planning projects: Although the main targets regarding the performance of a factory are typically achieved, the costs and time goals are only rarely met [7]. As a reaction to these problems, many companies introduced standardization approaches along with their factory structures [8], [9]. Starting with the modularization of the product itself, these methods slowly reached the production and factory. Especially in the planning phase of a new production, factory standards can achieve great reductions in planning times, costs and complexity [10]. Pioneers in the standardization of production and factory facilities are automobile OEMs. By their big unit numbers, these OEMs can compensate the initial investments for the development of the factory standards by later scale effects during series production.

As small and medium-sized enterprises (SMEs) often do not reach scale effects to that extent and cannot afford separate departments that are just in charge of the maintenance of those standards, the idea of factory standards is only rarely applied in SMEs. This paper investigates if for SMEs a workaround might be possible, in which a factory standard for a whole industry sector is developed by an inter-branch association or even a third party. For this, an evaluation model for the standardization potential in different industry sectors is developed. This model is then applied to the German economy and the overall standardization potential within these sectors is estimated.

II. Challenges in Factory Planning for Small and Medium-Sized Companies

Before developing the evaluation model regarding the standardization potential in branches with a high proportion of SMEs, the challenges in factory planning for these companies must be analyzed in further detail. There are several definitions for SMEs with different criteria. In this paper the following classification based on a definition by the European Commission will be used:

> "*Small and medium-sized enterprises employ less than 250 people and generate a yearly turnover of up to 50 million euros or report a balance sheet total which does not exceed 43 million euros* [11]."

Based on the small enterprise size, factory planning projects in these companies often have a unique character, and a specific factory planning department is economically not reasonable [12]. The planning tasks are hence conducted by employees that are later on also heavily affected by the results. The involved planners normally collaborate in a factory planning project "once in a lifetime" or at least rarely as their daily business are normally completely different. A systematic planning methodology is hence often missing so that the

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success of the overall project depends strongly on the pragmatism and intuition of the involved planners.

Due to the high number of planning alternatives and the multitude of restrictions that have to be considered in the planning project, practical planners often tend to say that every planning project is completely different [12]. This opinion which can frequently be found in SMEs leads to a low application of the factory standards. Another reason that factory standards are not widely applied in SMEs is that the capacities for its development are often missing. Due to the size of the companies, there are normally no extra factory planning departments that can later on also fulfill necessary functions as e.g. updating or adjusting the factory standards.

The low application of factory standards in SMEs overall leads to extra cost and time efforts in the planning phase of a new factory. This is mainly due to low scale effects e.g. in the procurement of machinery and equipment but especially inefficiencies in the planning phase because every factory has to be planned completely new instead of using “off-the-shelf solutions.” The potentials for costs and time reductions during factory planning projects were investigated in the empirical survey “Excellent Factory Planning” 2014 by WZL of RWTH Aachen University (Fig. 1) [13]. The potentials of factory standards regarding cost savings can be estimated with ca. 15%. The time-saving potential in Greenfield projects is around 23% and in brownfield projects around 12%. These potentials are often not exploited in SMEs, which endangers their competitive position in the long-term.

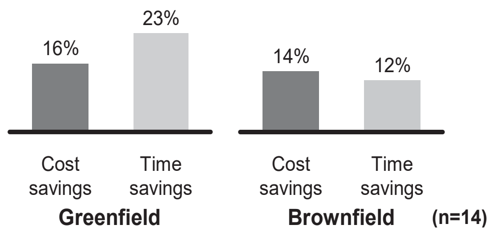

Fig. 1 Potentials of factory standards [8]

As cost and time pressures in globalized markets force SMEs to increase their profitability, factory standards seem to be a promising approach. Since a development of those standards is often not economical for single companies, an elaboration of those standards for a whole industry sector with similar production circumstances must be the solution. This elaboration could, for example, take place in a sector-internal cooperation. As it is expected that competing companies might not be eager to collaborate, if the production standards have a big meaning for the competitiveness of the company, the standards could also be developed by a third party as e.g. an engineering office, which has a deep insight into the sector.

III. Evaluation Model of Standardization Potential in Different Industry Sectors

In this chapter, an evaluation model will be developed that helps to identify branches in an economy that are interesting for the development of a sector-wide factory standard. In a first step, the main requirements for an evaluation model are defined before the key performance indicators of the model are introduced.

A. Requirements for Evaluation Model

The requirements that the model generally has to fulfill can be clustered into content and function requirements (Fig. 2).

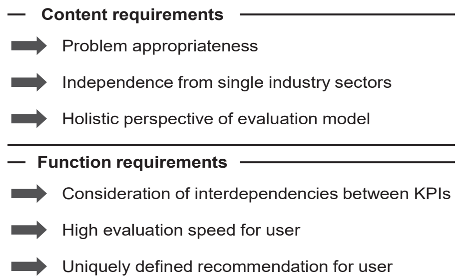

Fig. 2 Requirements for the evaluation model

Regarding the content requirements, the evaluation model should be appropriate to the problem that is addressed. This means that the evaluation model should be able to assess the standardization potential across different industry sectors without overcomplicating the problem. Additionally, the model should be able to evaluate different branches so that it has to be independent of specific industry sectors. Finally, the model should have a holistic perspective so that key performance indicators (KPIs) from all different company areas have to be considered.

A functional requirement for the evaluation model is the consideration of the interdependencies between the single KPIs. The exact assessment of the KPIs for each particular industry sector, therefore, makes a minimum degree of segmentation of the industry branches necessary, which the model has to consider at this point without affecting the evaluation speed too negatively. As the last requirement, the model should be able to give a uniquely defined recommendation to the user without leaving him in doubt about his further actions.

B. Key Performance Indicators within Evaluation Model

On the basis of the mentioned requirements, the evaluation model was developed. The main target of this KPI system is to identify those industrial sectors that are highly promising for a sector-internal standardization. According to the detail that the user would like to achieve, two different levels of the KPI system exist. A “quick check” variant that enables a fast assessment of different branches and in-depth analysis that helps to identify “sub-branches” within an industry sector with high standardization potential. The in-depth analysis can be mainly described as an addition to the quick check variant, which uses a more detailed set of KPIs. In the following, only the “quick check” variant will be introduced giving a good impression also about how the in-depth analysis works. The evaluation system for the quick check can hereby be classified into four basic categories: general KPIs, competition, profitability and production (Fig. 3). The basic indicators of these four categories and their particular effects on the attractiveness for standardization within the particular industry sectors will be described in Fig. 3.

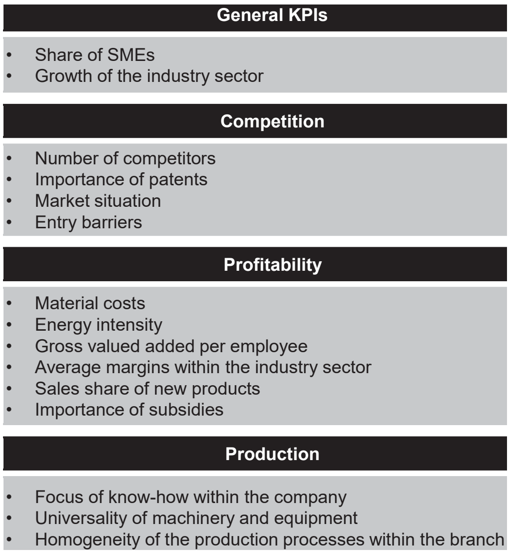

Fig. 3 Overview of KPIs in evaluation model

In the category of general KPIs, two basic indicators can be differentiated: the share of SMEs within the industrial sector and the growth of the branch. A high share of SMEs within the branch makes a sector-wide standardization approach more attractive as the benefit for the relevant companies seems to be more promising due to higher scale effects. The growth of the sector is measured by the increase in sales for the whole branch. A high growth of a sector makes the application of standards more attractive. The reason is this growth can only be realized by expanding the production capacities and building up new facilities.

In the competition category, basically, four KPIs are analyzed: number of competitors, the importance of patents, market situation, and entry barriers. The number of competitors is an indicator for the intensity of competition within the branch. Current studies show that sectors with a more intense competition are characterized by higher margins for the single companies [14]. This is mainly due to a better prioritization of lucrative orders by the companies and competition that is not only driven by cost advantages but also other product related customer benefits [14]. A higher competition within the branch leads to a growth strategy, realizing high margins at the same time. This makes the application of standards more attractive. The importance of patents is a second indicator within the competition category. In an industry sector that has a huge number of patents, the competition will be lower than in other branches. This is due to the fact that the single companies can rely on their intellectual property or patents as their competitive advantage, which reduces the cost pressure within production and hence the motivation for the application of factory standards. The third indicator market situation basically measures, if the markets in the industry sector can be identified as a buyers´ or a sellers´ market. Assuming that buyers´ markets are usually characterized by products that already show a high level of standardization and products on sellers´ markets should have a much higher level of individuality, the potential for standardization is much higher on buyers´ markets. As the last indicator, the entry barriers for new competitors in an industrial sector can be used as a KPI. If a market shows high barriers as e.g. scale effects by existing companies, high identification by customers with products, etc. the rivalry within the sector is reduced [15]. This again means that the cost pressure is not as high as in markets with lower entry barriers, which leads to a lower interest in a sector-wide standardization.

In the third category profitability overall six different indicators were developed. A huge importance of material costs leads to a lower importance of other cost categories, which means that process standardizations are less urgent and hence the will for standardization is lower in the companies. The same line of argument can be applied to the second indicator, which is the energy intensity. It measures the share of energy costs in relation to the overall sales within the sector. The third indicator addresses the gross valued added per employee. A high value for this indicator normally shows that the level of automation is high in this branch [16], which means that the cost reduction potential by further standardizations seems to be quite small. The fourth indicator is described by the average margins within the branch. If these margins are above average, the companies within the branch are normally on a growth strategy and expanding their production capacities. This is why also standardization plays an important role within these companies to ensure that this growth is realized at minimum costs. Another indicator is the sales share of new products. This indicator basically measures the importance of new products within an industry sector, which also implies the focus on innovation within the sector. The high number of innovations leads to a high complexity within the company and hence can only be handled by extra measures as standardization. As the last factor, the importance of subsidies is considered within this category. Subsidies in a branch lower the cost pressure for the single companies [17]. This is why it is assumed that standards are more important if there are no subsidies in a branch.

In the last category, three basic production indicators can be differentiated. The first indicator measures the focus of the know-how within the company. Basically, it can be differentiated, if this know-how is more focused on the product itself or the production process. If the process know-how plays the bigger role, the motivation for standardization within the company should be lower as the danger is higher to limit the innovational power that comes from the production processes themselves. A second indicator is the universality of machinery and equipment. If this equipment can quite generally be used for different products, the possibilities for standardization are much higher than in the case of very individualized equipment. The last indicator measures the homogeneity of the production processes in the branch. If there are quite similar production processes within an industry sector, it is easy to standardize the processes also for different companies.

C. Overall Index for Standardization Potential

To enable a comparison between different branches in one overall indicator, the introduced KPIs from the previous section were brought into an overall index. For this, a comparison of couples between the single indicators was made in a first step. Additionally, a scale for each indicator was developed. The resulting weighting of the indicators as well as the measured values can then is multiplied and summed up to the overall value. The result is the overall index for the standardization potential within an industry sector. In the following, this methodology will be applied to the German economy with its basic branches.

IV. Analysis of German Industry Sectors

In this chapter, the developed evaluation system will exemplarily be applied to the sectors in German manufacturing industries. For this, in a first step, the German industry will be described briefly. After this, the results of the analysis will be presented.

A. Introduction to German Industry Sectors

Production has a long tradition in Germany, and manufacturing industries still account for more than one-fifth of the jobs in German economy [18]. Manufacturing industries contribute with approximately one quarter to the gross value added in Germany every year, which emphasizes their importance for prosperity in Germany [19]. In the following, 12 different industry sectors within manufacturing industries in Germany will be analyzed in further detail (Fig. 4).

Although the term “industry sector” has many different definitions, in this paper it basically describes a segmentation of the manufacturing industries from a product point of view. The mentioned 12 sectors can also be found in other countries with similar basic structures so that the results of this analysis should be transferrable to the manufacturing industries of other countries.

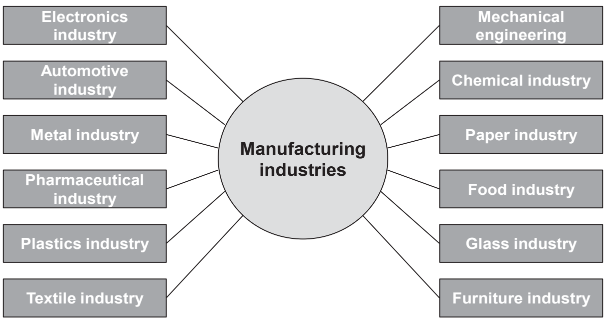

Fig. 4 Industry sectors within manufacturing industries in Germany

B. Results of Analysis for German Industry Sectors

Based on the presented evaluation system in chapter III, the German industry sectors were analyzed to measure the attractiveness for a sector-wide standardization. The results of this evaluation are shown in Fig. 5, in which an extra axis for the overall sales within the industry sector was added. This additional axis basically measures the synergy effects in the planning phase by using the yearly sales in the industry branch, which increases the attractiveness for SMEs for the collaboration in the branch. The score within the evaluation system as well as the yearly sales is marked on a relative scale. According to existing portfolio approaches, the resulting data points are clustered into four basic quadrants.

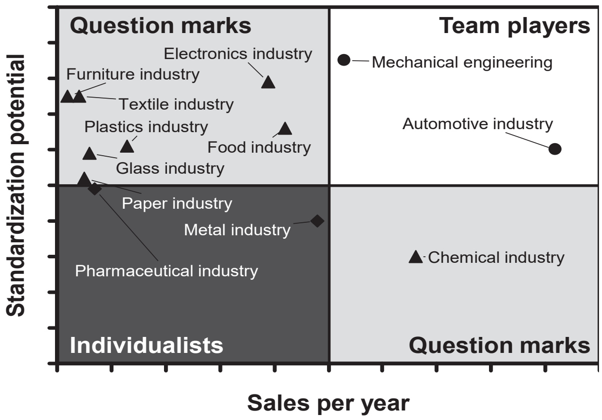

Fig. 5 Attractiveness of industry sectors for standardization in cooperative approaches

The group of team players is characterized by high yearly sales as well as a high score for the standardization potential, which makes a sector-wide standardization very attractive. In Germany, the branches of the automobile industry and mechanical engineering can be allocated to this quadrant. In contrast to that, the group of individualists shows a low standardization potential and low overall scale effects due to a low sales volume. In these industries, standardization is not that lucrative. In Germany, these attributes only fit for the pharmaceutical industry and the metal industry. The industry sectors with a high standardization potential and a low sales volume or the other way round, are named question marks. For these branches, it has to be analyzed individually whether a sector-wide standardization is really promising enough for the single SMEs or not.

Using the results of the empirical survey “Excellent Factory Planning” 2014 by WZL of RWTH Aachen University [13] (Fig. 1), the overall cost saving potential for each industry sector through the application of sector-wide factory standards, can be calculated in average using some basic indicators for the German industry sectors [20]. The results in Fig. 6 were calculated by a multiplication of the yearly investments in machinery and equipment in the industry sector, the average cost savings in brownfield projects and a relative factor according to the potential standardization score from Fig. 5.

As the investments in machinery and equipment are not the overall investment in a new production facility (e.g. investments in land or building are missing) and the brownfield potential is lower than the Greenfield potential, these cost potentials are estimated "to the safe side." In addition, here the highest potentials can be found in the automotive industry and in mechanical engineering. The potentials in a single branch sum up to an overall volume of approximately more than 2.6 billion €. This shows the high potential and relevance of factory standards that are developed especially for SMEs within specific industry sectors.

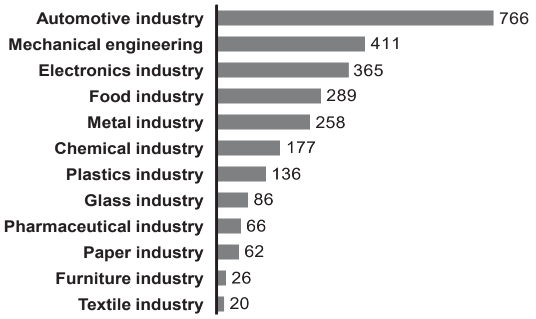

Fig. 6 Cost reduction potentials for industries in Germany [Mio. €]

V. Conclusion and Outlook

As SMEs are exposed to the same challenges as bigger companies in globalized markets with shorter product and process lifecycles but lack the opportunity of own factory planning departments, the application of factory standards is much lower for these companies. This paper presented an evaluation model, which measures the standardization potential within single industry sectors in an economy that is especially characterized by a big share of SMEs. This model was then applied to the German economy identifying the most promising sectors for sector-wide factory standardization.

In the future, this model should additionally be validated for other economies. Furthermore, the evaluation model just helps to identify the most promising industry sectors but does not give any hints how the factory standard should be developed within the industry. For these different organizational models as a sector-internal association of different SMEs or the development by a third party as e.g. an independent engineering office must be analyzed and benefits and disadvantages of both organizational models should be compared.

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