

PLANNING FLEXIBLE HUMAN RESOURCE CAPACITY IN VOLATILE MARKETS

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Abstract: Manufacturing companies face stronger fluctuations in customer demand driven by volatile markets with ever shorter lead times and decreasing predictability. Manufacturing companies therefore need to increase their responsiveness by organizing the flexibility within their personnel capacity which is one of the most relevant cost factors in manufacturing. Thus the flexible adaption of human resource (HR) capacity represents a significant advantage in competitiveness for future business sustainability. This is in conflict with the current situation as manufacturing companies do not have planning tools or methods for a systematic planning and utilization of HR-flexibility in volatile markets. Although manufacturing companies already utilize several instruments to adapt HR capacities to markets demand (e.g. temporary work, working time accounts). The planning and application of these instruments is often based on experience rather than on a systematic methodology. Systematic planning of HR flexibility can only be ensured by proactive planning at the tactical log-termed level. Therefore a reference framework is required, that leads companies to dimension their HR-flexibility on the long term and make them able to use the right flexibility instruments from long term to short term periods.

The German research project “KapaflexCy” aims at creating high flexible utilization of HR-capacity in manufacturing companies using industry 4.0 principles like mobile devices and social media. To ensure the systematic utilization of the right HR-flexibility a reference framework is created. The paper describes the need for systematic planning of HR-flexibility and the developed reference framework.

Keywords: volatile markets, resource availability, human resource flexibility, capacity planning.

1. INTRODUCTION

Manufacturing companies are more and more subject to strong fluctuations in customer demand that cannot be predicted in a reliable manner using today’s forecasting methods [1]. Despite the environment of volatile markets, companies strive to achieve high degrees of supply availability within short lead times while maintaining low inventory levels and reasonable capacity utilization [2]. To avoid lost sales as a result of inflexible resources and to improve supply availability, companies require not only flexible production facilities and reactive supply chains but also a long-term oriented and systematic planning and control of manpower through the use of human resource (HR) flexibility instruments. Especially companies that derive a large share of value added in the fields of manual manufacturing and assembly are, therefore, forced to ensure their responsiveness to market fluctuations by increasing the flexibility of their labor utilization [3, 4]. This challenging task requires a systematic planning and utilization of HR-capacity.

2. VOLATILE MARKETS

The term of volatile markets is not a new one. In 1994 Hesberg wrote about increasingly volatile markets in the area of the insurance industry [5]. So far the term “volatile markets” was mostly used in connection with the financial markets where stock prices reflect the daily market

fluctuations concerning purchases and sales. Up to then the term of volatile markets was used to evaluate the fluctuations of financial contracts, e.g. stocks. Nowadays the term is also used as a description for the characteristic fluctuations of markets, sales figures or the development of customer-demand, also in the manufacturing sector.

Volatility is derived from the Latin word "volatilis". Among other things it can mean flying, volatile or fast [5]. In the German Duden volatility is defined as the "degree of fluctuations of prices, equity and foreign exchange rates, interest rates or even entire markets in a short period of time" [6]. Volatility does not describe the direction, but the range of fluctuations. The greater the range of the fluctuations, the more volatile the underlying index is evaluated. On the one hand high volatility of an index is a sign of opportunities, but on the other hand it also describes high potential of risk. In economics, the volatility is often expressed as a percentage and serves as a measure of risk. In the field of manufacturing markets seem to be increasingly volatile, which is reflected by stronger fluctuations in sales and manufacturing volumes [5].

Global markets and a strong interrelation between the manufacturing and the financial sector are reasons for increasing volatility in manufacturing. The significant impact of this interrelation on the global manufacturing industry could be observed in the global economic crisis following the Lehman Brothers’ bankruptcy in September 2008. Germany, with more than 7 million workers in the manufacturing sector

is a typical manufacturing country where more than one in every four euros is earned directly in manufacturing [8]. In 2009 the turnover index of the German manufacturing sector fell by nearly 30% from October 2008 to January 2009 as Figure 1 shows [9]. The assessment of the business environment for the manufacturing sector as measured by the Ifo-economic-climate index also decreased by almost 30 points to a level of 85% from 2008 to 2009 [8]. A few months later both indicators showed a massive swing back in the other direction. In total, the two movements of the turnover index formed a fluctuation of 56% in 12 months.

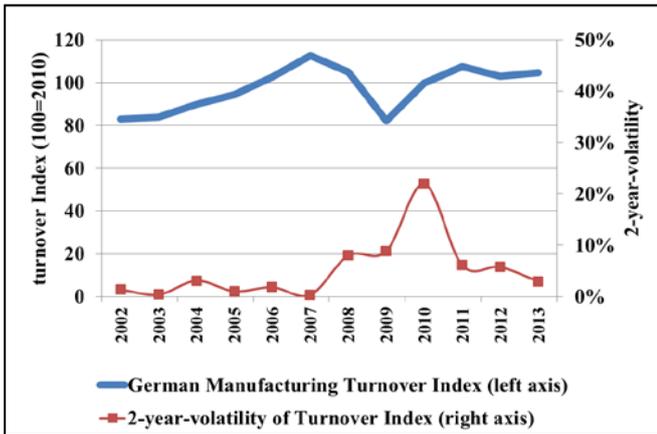


Figure 1: Development and volatility of the Turnover Index in the German manufacturing sector.

Manufacturing companies have to manage customer demand volatility driven by short-term company- or customer-specific effects, seasonal fluctuations, the product life cycle and cyclical market volatility [10]. Short-term volatility is often caused by large orders of one or a few customers, which are handled in manufacturing as a project. These project orders however exceed the conventional manufacturing levels and thus require a significantly increased manufacturing capacity at short notice. In addition, seasonal influences on companies' sales are driven by seasonal characteristics or product-specific effects. They also occur due to fiscal year-based effects e.g. decrease of inventories or specific budget situations. Long term effects like the product life cycle used to reach a long-term constant level between short phases of ramp-up and ramp-down in the past. Today the typical product life cycle is a much shorter cycle with a pronounced upturn and downturn phase. The fluctuations described are notably interrelated with cyclical effects that have a strong and long-term impact on capacity utilization. The effects do not appear in isolation, but are interrelated. The result can be either a weakening of the overall effects or a reinforcement of the overall effects. Especially the reinforcement effect, challenges the companies in managing their manufacturing capacities.

3. OBJECTIVES OF MANUFACTURING COMPANIES

In today's volatile markets, where fluctuations become stronger and occur more often, the paradigm of capacity flexibility becomes more and more important. The traditional objectives of production planning and control remain

essential even under the conditions of volatile markets. Short delivery times, high delivery reliability at reasonable utilization of production capacity combined with low inventory levels are still relevant objectives for manufacturing companies. In the past high utilization rates of resources (e.g. machines, workers) were in focus. Today short delivery times at low inventory levels are the major objective of a market-based managed company (see Fig. 2).

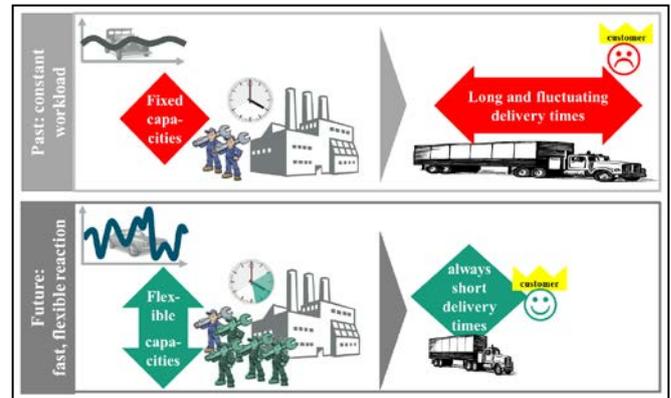


Figure 2: Paradigm of capacity flexibility for manufacturing companies.

In the past companies used to be able to buffer high volumes of customer orders by increasing delivery times, but in today's volatile markets, customer orders need to be produced immediately or will be lost to a competitor. To produce immediately requires the possibility to react very fast without having enough time to build up new production lines or employ new workers. The fast reactions required become possible through technical and personnel over-capacities. Concerning the technical capacity e.g. in assembly systems, over-capacity is already provided by typical types of assembly organization implemented in many companies. Mounting from the lean management, an example for technical over capacity is a u-shaped assembly-line [11]. In relation to the output of these assembly systems it is possible to operate these systems with a different number of workers. If a typical u-shaped assembly line is operated by one worker at an output level of 20 products per shift, two workers would nearly be able to produce 40 products in the same assembly system. In the future the necessary personnel over-capacity is created by an intelligent use of HR-flexibility instruments. In addition to increase flexibility in costs, global competition requires companies to differentiate by offering a consistently high degree of delivery for their customers. Therefore, companies are forced to systematically plan and organize a high level of productivity. In volatile markets with alternating periods of low and heavy load of customer demand this becomes even more important. One approach to achieve this challenging objective is the concept of capacity flexibility. In the manufacturing sector, where still a lot of personnel is employed, in particular the flexible capacity of human resources directly involved in the creation of value becomes crucial.

4. FLEXIBILITY AND CAPACITY FLEXIBILITY

Flexibility is considered to be a measure of the ability of a system to adapt to changing environmental conditions [12, 13]. Flexibility represents a potential for companies that can be used, but does not have to be used. Generally, companies have two possibilities to generate flexibility for themselves. The first option is to provide over-capacity; on the other hand companies can provide flexible resources. Both options involve costs which have to be regarded particularly under the focus of the uncertainty of the utilization of flexibility.

The Organization for Economic Co-operation and Development (OECD) differentiates four fields of flexibility for companies [14]. These are the types of internal, external, numerical and functional flexibility. The internal flexibility includes all changes in the internal corporate structure. External flexibility includes all kinds of interaction with other companies and markets. The variation of the number of employees is described by the numerical flexibility (flexibility in quantity). This dimension of flexibility is an important lever of competitiveness for manufacturing companies. Often a great variety of different employment modes are provided parallel by manufacturing companies (e.g. permanent workers, temporary workers, holiday workers, mini-jobbers). This requires extending the traditional view of numerical flexibility to a structure numerical flexibility, where the number of workers in a certain employment mode becomes relevant for a company's long-term capacity planning. Furthermore in the OECD definition the dimension of functional flexibility is described by the versatility of the skills of the workforce.

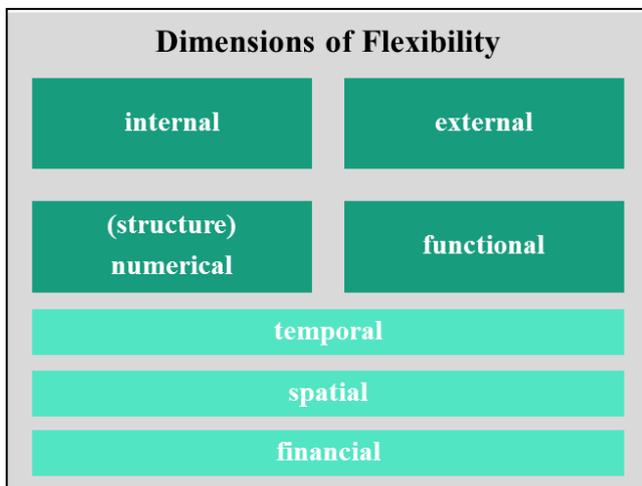


Figure 3: Dimensions of flexibility for manufacturing companies.

In addition to these four dimensions Reilly adds the dimensions of the temporal, spatial and financial flexibility as shown in Figure 3 [15]. Temporal flexibility represents all instruments allowing the extension or reduction of the operating time of the manufacturing line or the variation of the staff's working time (flexibility in time). This dimension includes HR-flexibility instruments as additional shifts or extended shifts. In the case of reduced capacity requirements

reduced or shortened shifts are possible at personal or collective ranges.

For the labor-intensive sector of manufacturing, with more than 7.7 million employees in Germany, the concept of capacity flexibility summarizes all approaches and instruments that enable companies to adapt their workers capacity to meet the fluctuating demand situations in volatile markets productively [2]. The current study of the Fraunhofer Institute for Industrial Engineering called "Manufacturing work of the future – Industry 4.0" describes the future needs for flexible HR-capacity in the manufacturing sector. Already today nearly 72% of more than 660 surveyed companies indicate to face strong fluctuations in markets demand. A majority of 97.9% of the companies indicate that the flexible utilization of their manufacturing personnel capacity becomes important for the competitiveness of the company in the next five years [16].

5. GENERAL STRATEGIES FOR THE ADAPTION OF FLEXIBLE CAPACITIES IN MANUFACTURING

In literature three different general capacity adaptation strategies are known (see Fig.4). These are the strategies of emancipation, synchronization and partial emancipation [17, 18].

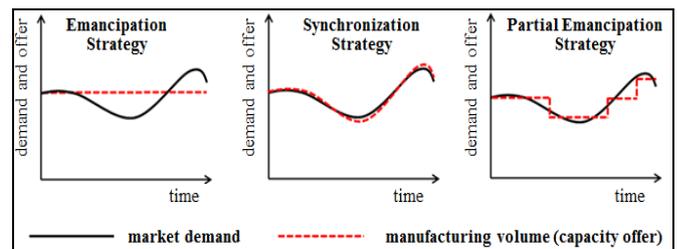


Figure 4: General capacity adaptation strategies.

In the strategy of emancipation the production volume is not coupled with the markets demand. Hence in this strategy, the manufacturing capacities are not adapted to the needed capacity demand. The advantages of the emancipation strategy are consistently high rates of capacity utilization, and low costs of change. In this strategy the idle-time costs are very low. On the other hand high costs for capital commitment, inventories and for the adaptation of production to new products requirements and furthermore long delivery times are the disadvantages of this strategy.

Contrary to the emancipation strategy the synchronization strategy adapts the manufacturing capacity to the markets demand. Using approaches like "production on demand" minimal costs for inventories and capital commitment of finished goods occur. The manufacturing has to be strongly designed to a customer-orientation. Disadvantages of this strategy are high costs of change and adaptation in manufacturing and strongly fluctuating rates of capacity utilization, which must be compensated by the use of flexibility instruments. Otherwise these fluctuations are associated with high costs of idle capacity and overload situations.

The partial emancipation strategy strikes a balance between the emancipation and the synchronization strategy. The manufacturing capacity is adapted gradually to the markets demand.

What kind of adaptation strategy suites best for a manufacturing company, results by concerning the specific market volatility, the manufacturing equipment and the costs that are caused by flexible manufacturing capacities. Anyway, market-oriented strategies with the objectives of low inventories and short delivery times require a high degree of flexibility in manufacturing capacity.

6. HR-FLEXIBILITY INSTRUMENTS

In recent years, a number of HR-flexibility instruments to adapt the personnel capacity were established within the German industry. An overview of the variety of HR-instruments can be found in literature [19]. Two major groups of HR-flexibility instruments are distinguished, which cause different capacitive and cost-sided effects.

The number of workers in the company can be adapted by different modes of employment (flexibility in quantity). This includes traditional and flexible modes of employment like permanent or temporary workers. In addition, the other group of instruments focuses on adapting the working time by allowing for variation in work duration or allocation of working hours e.g. using additional shifts (flexibility in time). Instruments for deviations from the normal working times with respect to the duration of working time are known as chronological models (e.g. part-time). Instruments to shift the position of the working time are called chronometrical models (e.g. flexible start or end of working time). The flexible working times can be balanced by working time accounts. Working time accounts balance the actually worked and the planned working hours. They are used in different temporal characteristics concerning short-term and long-term compensation periods. Working time accounts are usually limited by borders, so that excessive build-ups or reductions are limited. In the German manufacturing sector more than 70% of the companies already provide working time accounts for their workers and thus enable the temporal dimension of HR-flexibility [20].

Temporary work also is an important HR-flexibility instrument for manufacturing companies [21]. As Figure 5 illustrates, nearly 900,000 people were employed in this flexible form of employment in Germany in 2011 [22]. Temporary employment relationships have been increasing almost continuously over the last couple of years in Germany with annual growth rates of about 10%. The primary benefit of temporary work for manufacturing companies is the ability to increase appropriate staff quickly in economic upturns while being able to reduce manpower fast in an economic downturn or during downturn seasons. However, temporary work does not provide a high level of job security to employees. Nonetheless, nearly 50% of all temporary workers are working for manufacturing companies in Germany [22, 23].

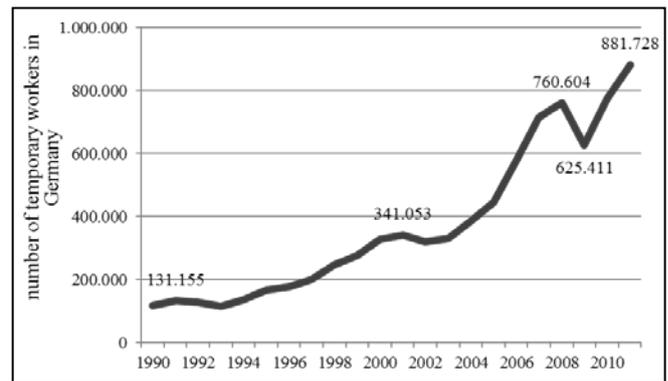


Figure 5: Development of temporary employment in Germany.

7. REFERENCE FRAMEWORK FOR DIMENSIONING, PLANNING AND UTILIZATION OF HR-FLEXIBILITY

The specific characteristics of volatile markets on the one hand and the number of applicable HR-flexibility instruments with different effects in capacity and costs on the other hand, make it necessary for manufacturing companies to systematize the utilization of HR-flexibility instruments. Therefore it is necessary to dimension the size of usable instruments in the long term to make them available on the short term. Furthermore a strategy for flexibility defines which instruments have to be preferred and which have to be neglected during a medium term period. Short-term decisions concerning the utilization of flexibility instruments can then be made on the basis of a long-term oriented strategy. This allows a cost-effective utilization of instruments considering all short-term to long-term volatility effects. The procedure to use HR-flexibility instruments in a systematic way using a reference framework for dimensioning, planning and utilization of HR-flexibility instruments was developed by the German research project KapaflexCy. The major objective of the KapaflexCy project is to develop a highly flexible workforce management system that allows companies to control their manufacturing capacity together with their manufacturing workers. To realize this objective, the dimensioning of the necessary flexibility instruments is required. Hence the framework represents a scope for action. Thus the description of the reference framework is a first result of a methodology for the systematic utilization of HR-flexibility instruments in manufacturing.

The reference framework works like a hierarchical planning framework and is described in steps called application scenarios (see Fig. 6). An application scenario describes the certain dimensioning, planning and control activities, concerning the flexibility instruments for a defined period of time. Long term oriented decisions serve as a scope for action for short term activities. The decisions on the long-term are made on a tactical level, by the management. The short-term planning and control tasks are performed by production engineers, foremen or directly by the manufacturing workers. To enable the systematic utilization of HR-flexibility, it is important select and dimension the flexibility instruments with a long-term scope (1). In this first step it is determined which instruments can be used in the company generally.

Furthermore the extents, to which these instruments are available, have to be defined. The dimensioning task is mainly based on the market scope of the company, the volatility of the markets the company supplies, the risk and impact of economic crises and on the existing customer ordering patterns. This step is especially necessary for the early adoption of operating agreements about the utilization of certain flexibility instruments between the company's management and the works council. Furthermore, storage and market supply strategies should be considered in this step as they have significant impact on the need for flexibility. It has to be taken into account whether the company decides for market-oriented production directly to customer orders or decides to supply markets using a make to stock strategy. The dimension of the HR-flexibility instruments determines the availability of instruments for a period of one to several years. Therefore a wide variety of instruments should be integrated in the dimensioning process. During this process capacity effects, cost effects and financial liquidity effects of the HR-flexibility instruments have to be evaluated. In a second step the medium-term flexibility strategy has to be determined (2). Here the dimensioned instruments are prioritized for different market situations, e.g. seasonal position. The strategy of flexibility applies for several months and represents the direction for all subsequent planning and control activities within this period. The extent of economic crises on the company's plans, have to be considered in the design of the flexibility strategy. If economic crises are predicted to occur regularly, it has to be considered to provide a sufficient buffer of flexibility using the HR-instruments. In addition management tools have to be developed to build up the crisis flexibility on time. An example of a flexibility strategy is to use working time accounts to compensate volatility. In this case working time accounts are used as prioritized instrument to compensate economic, seasonal and other short term fluctuations in HR-capacity demand. The volumes of the working time accounts that are required in the long term have to be build up by prioritizing instruments such as additional shifts or shift extensions during the working time account's ramp up phase. In this strategy all instruments that build up working time accounts are prioritized in order to achieve the ramp up target value regularly.

In addition, the particular flexibility strategy of the company has to be oriented at the stage of the product life cycle in which the company's products are and at the actual seasonal situation (e.g. high season, low season). In the third step the standard shift schedule is created (3). Here a shift schedule is developed, which is sufficient to cover the medium-term capacity needs of the markets. Beyond that all predictable information concerning reduced HR-capacity, such as illness rates, vacation or training is listed in the standard shift plan. In doing so the basic framework of the company's HR-capacity is designed. In the fourth step the medium-termed workforce planning takes place (4). The HR-capacities listed in the standard shift schedule are adapted to the actual, fluctuations of the markets demand. If necessary sales forecasts for the coming weeks and months are involved within this planning level. The planned adaptations of the HR-capacity have to be made according to the selected strategy using the prioritized flexibility instruments. Possible instruments during this step are variations of working hours and variations of the occupation intensity of the manufacturing lines. In Germany decisions concerning e.g. working times have to be made in agreement with the works council. The standard shift schedule for the next weeks or months can be adapted based on the determination of operating times through additional or reduced shifts. After that the available manufacturing workers can be attached to certain shift slots in the shift schedule. If this requires adaptations in staffing levels HR-instruments have to be selected that are consistent to the actual flexibility strategy. In the fifth planning step short termed but plannable capacity adaptations have to be compensated on a planning horizon of a few weeks (5). These adaptations occur due to additional or cancelled customer orders, machine break downs or a lack of material. In addition, short-termed but planable shift-substitutions are planned in this application scenario. These situations are compensated in the shift-plan using instruments of HR-flexibility like borrowing or lending workers from or to other manufacturing sections or activating temporary workers. This step completes the planning process for a period of the next weeks. Regarding the reference framework it is no longer spoken of planning from this step along, but by controlling the utilization of HR-capacity, since the events triggering interventions occur at short term notice.

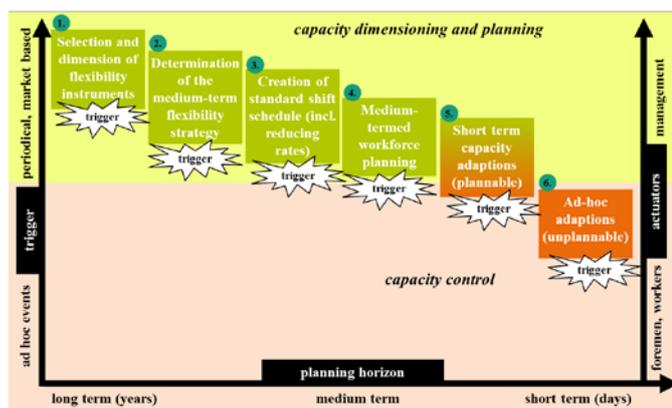


Figure 6: Reference framework for dimensioning, planning and utilization of HR-flexibility.

In the last application scenario lead times are only up to a few days. Hence the necessary application of flexibility instruments cannot be planned with sufficient preparation time, but must be controlled mostly ad hoc. This strongly reduces the selection of HR-instruments being applicable in this step. In the last step events being triggered with very short lead times are compensated in capacity (6). These events are triggered by the workers or by market-based effects. In case of unplanned shift-substitutions due to illness or personal emergencies, instruments to extend operating hours for the remaining workers are useable. Furthermore instruments to compensate the missing occupation of the manufacturing line have to be selected. The selection of the instruments applied, again, has to be made under consideration of the actual flexibility strategy and the manufacturing organization (e.g. flexible occupation of u-shaped lines or fixed occupation of conveyer belts). This

requires to extend shifts for the present workers or to organize additional workers via borrowing models, pool employees or stand-by workers. The company uses the same flexibility instruments to adapt its HR-capacity at short notice if rush orders, machine break downs, material stock-outs or quality problems occur. Even in this step the flexibility strategy should be considered as the framework for selecting HR-instruments.

The procedure described by the reference framework is based on the systematic dimensioning of HR-flexibility instruments. Only when the type and the ranges of the flexibility instruments were selected systematically the optimal utilization of the instruments is ensured in the short term steps. For this reason, it is the objective of the KapaflexCy project to develop a methodology for dimensioning, which is aligned with the market's capacity needs and enables the selection of flexible instruments based on economic indicators. Such a methodology supports to improve productivity and competitiveness of manufacturing companies and also secures employment for employees.

8. ACKNOWLEDGMENT

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REFERENCES

- [1] Bullinger H.-J., Spath D., Warnecke H.-J., Westkämper E., *Handbuch Unternehmensorganisation – Strategien, Planung, Umsetzung*, Springer, Berlin, 2009.
- [2] Lödding H., *Verfahren der Fertigungssteuerung*, Berlin: Springer, 2008.
- [3] Spath D., *Global Challenges and the Need for Enhanced Performance*, Presentation, Professional Training Facts, Stuttgart, Nov. 11th 2008.
- [4] Oechsler W. A., *Personal und Arbeit – Grundlagen des Human Resource Management und der Arbeitgeber – Arbeitnehmer-Beziehungen*, Verlag Oldenbourg, Munich, 2011.
- [5] Hesberg, D., *Ist die Externe Rechnungslegung der Versicherungsunternehmen überflüssig?*, in: Risiko, Versicherung, Markt, Karlsruhe 1994.
- [6] McKinsey Germany, *Willkommen in der volatilen Welt*, McKinsey & Company Inc., 2010.
- [7] Duden-Online. Bibliographisches Institut GmbH. Internet: <http://www.duden.de> (09.11.2013).
- [8] Ifo Konjunkturperspektiven 02/2013, *Results of the Ifo Business Survey in Germany for February 2013 in all details*, ifo Institute, Munich, 2013.
- [9] German Federal Office of Statistics, Database of Indicators, www.destatis.de, March 3rd 2013.
- [10] Spath D., *Zukunft der Arbeit – Arbeit der Zukunft*, Zukunftsforum 2013, Stuttgart, 2013.
- [11] Lotter, B., *Montage in der industriellen Produktion*, Springer Verlag, 2013.
- [12] Hackstein, R., *Produktionsplanung und -steuerung*, Düsseldorf: VDI-Verlag, 1989.
- [13] De Toni, A., Tonchia S., *Manufacturing flexibility: A literature review*, International Journal of Production Research, 1998, 36:6, 1587-1617.
- [14] Organisation for Economic Co-operation and Development - OECD, *Labour market policies for the 1990s*, Paris, 1990.
- [15] Reilly P., *Balancing Flexibility – Meeting the Interests of Employer and Employee*, Burlington, Gower, 2001.
- [16] Spath, D. et al, *Produktionsarbeit der Zukunft – Industrie 4.0*, Fraunhofer Verlag, 2013.
- [17] Steven, M., *Kapazitätsgestaltung und –optimierung*, in Kern, W, *Handwörterbuch der Produktionswirtschaft*, Schäffer-Pöschel Verlag, 1996.
- [18] Monauni, M., *Fixkostenmanagement: Strategischer Ansatz zur Flexibilisierung von Produktionskapazitäten*, Josef Eul Verlag, 2011.
- [19] Linnenkohl K., Rauschenberg H.-J., Gressierer C., *Arbeitszeitflexibilisierung*, Verlag Recht und Wirtschaft, Frankfurt, 2001.
- [20] Institut für Wirtschaftsforschung der Universität München, *randstad-ifo-flexindex, Ergebnisse 2. Quartal 2012*, 2012.
- [21] Vanselow A., Weinkopf C., *Zeitarbeit in europäischen Ländern – Lehren für Deutschland*, Workingpaper 182, Hans Böckler Stiftung, 2009.
- [22] Bundesagentur für Arbeit, *Leiharbeiter und Verleihbetriebe in Deutschland. Zeitreihe ab 1973*, in: Arbeitsmarkt in Zahlen – Arbeitnehmerüberlassung, Nürnberg, 2012.
- [23] German Federal Office of Statistics, Database of Indicators, www.destatis.de, March 3rd 2013.