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Optimal Measures in Production

Developing an Universal Decision Supporter for Evaluating Measures in a Production

Michael Grigutsch, Marco Kennemann, Peter Nyhuis

***Abstract*—**Due to the recovering global economy, enterprises are increasingly focusing on logistics. Investing in logistic measures for a production generates a large potential for achieving a good starting point within a competitive field. Unlike during the global economic crisis, enterprises are now challenged with investing available capital to maximize profits. In order to be able to create an informed and quantifiably comprehensible basis for a decision, enterprises need an adequate model for logistically and monetarily evaluating measures in production. The Collaborate Research Centre 489 (SFB 489) at the Institute for Production Systems (IFA) developed a Logistic Information System which provides support in making decisions and is designed specifically for the forging industry. The aim of a project that has been applied for is to now transfer this process in order to develop a universal approach to logistically and monetarily evaluate measures in production.

***Keywords*—**Measures in Production, Logistic Operating Curves, Transfer Functions, Production Logistics

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I. Introduction

IN the course of the recovering global economy and the accompanying competitive pressure, enterprises are confronted with new logistic challenges. By means of selected logistics measures in the production, manufacturing enterprises are able to counter this high competitive pressure. While enterprises drastically reduced their investment at the beginning of the economic crisis, they are currently faced with the challenge of investing available capital as well as possible in order to improve logistic performance. Enterprises therefore require a suitable model for creating a substantiated basis for monetarily and logistically evaluating measures in production. Decision making is supported by rendering measures in the production as well as the accompanying logistic and monetary impact evaluable.Numerous research projects at the Institute for Production Systems (IFA) indicated that measures with low investment costs were able to significantly improve the logistic performance of an enterprise.

Michael Grigutsch is research associate at the Institute of Production Systems and Logistics, Leibniz University of Hanover, Garbsen, 30823 Germany (corresponding author to provide phone: 0049-511-762-18193; fax: 0049-511-762-3814; e-mail: grigutsch@ifa.uni-hannover.de).

Marco Kennemann is research associate at the Institute of Production Systems and Logistics, Leibniz University of Hanover, Garbsen, 30823 Germany (corresponding author to provide phone: 0049-511-762-18187; fax: 0049-511-762-3814; e-mail: kennemann@ifa.uni-hannover.de).

Prof. Peter Nyhuis is director of the Institute of Production Systems and Logistics, Leibniz University of Hanover, Garbsen, 30823 Germany (e-mail: nyhuis@ifa.uni-hannover.de).

For example by harmonizing the work content, the throughput time variance can be reduced and the schedule reliability from the point of subsequent processes or the customer increased [1]. However, to this day no approach can be found in either national or international publications that allow measures in production to be universally and quantifiably evaluated with regards to their monetary and logistic effects [2]. Within the context of the Collaborate Research Centre 489 (SFB 489), a Logistic Information System (LIS) was developed based on requirements specific to forging. This monitoring and decision model is based on Microsoft Excel© and was realized using Visual Basic for Applications (VBA). The LIS allows selected measures to be evaluated based on logistic and monetary objectives (e.g., delivery performance and/or residual gains). The decision logic is based on a driver tree for determining residual gains (RG), Logistic Operating Curves and so-called transfer functions, which for example, with the aid of the sales/delivery performance function, make it possible to monetarily evaluate the improved logistic performance. In a further project a universal model shall be developed to monetarily and logistically evaluate measures in production [6].

II. A Logistic Information System for Evaluating Production Logistics Measures

A. User Environment

The LIS is based on a decision logic, which weighs selected logistic measures using logistic (e.g. schedule reliability) and monetary (e.g. RG) objectives. First of all, enterprises determine logistic and monetary objectives, which contain the RG or Work in Progress (WIP) level, thus allowing goals to subsequently be evaluated.The RG is a fundamental element in the structure of the LIS that allows the surplus value of an investment for an enterprise to be evaluated. This key figure is a well-established and tested approach in the industry [4], [10]. The RG (1) is defined by the tax rate (s), Earnings Before Interest and Taxes ($EBIT_t$) at the end of a period minus the product of the weighted average costs (CC_{mw}) and the total capital ($TC_{(t-1)}$) at the beginning of the period [6]:

$$RG = EBIT_t(1-s) - CC_{mw}TC_{(t-1)} \quad (1)$$

After defining the target values, monetary variables (e.g. material, manufacturing and inventory costs) are entered into the LIS for determining the RG as well as the feedback data from the production. The feedback data from the production refers to input and output data as well as work contents in order to make it possible to model the Logistic Operating

Curves. Modeling the transfer function requires entering the minimum sales increase that is achieved by improving the delivery performance. In a next step, various individual or combined measures are selected to improve the logistic performance. The LIS has a cockpit that lists the most important figures (see Fig. 1).

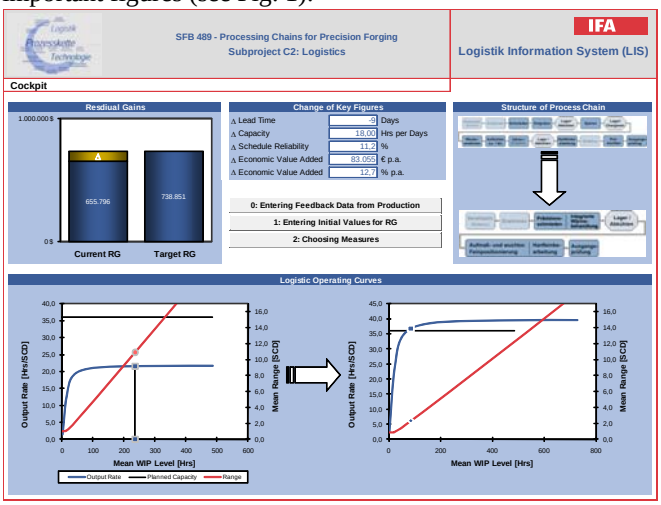


Fig. 1 Cockpit of the Logistic Information System

The cockpit compiles selected key logistic and monetary figures as well as the trends for the Output Rate and Range Operating Curves. The operating point which is calculated before and after the measure is introduced as depicted on the Logistic Operating Curves in order to graphically illustrate the WIP potential. Hence, the LIS supports the user's financial selection of suitable measures for increasing the logistic performance in the production [6].

B. Basic structure of the LIS

The correlation between measures in the production and the RG is modeled by means of a driver tree [7]. The driver tree is stored with a logic which allows the RG to be linked to variables that can be influenced by logistic measures e.g. schedule reliability. In contrast to the driver tree already described in professional literature, the interactions between logistic and monetary objectives are represented by means of so-called transfer functions in the LIS [6]. First and foremost, the transfer function represents the correlation between the delivery performance, delivery time and the sales quantity of the enterprise's revenues. The different factors involved (e.g., customer demands, competitors' market strategies or delivery performance) makes it difficult in practice to derive the curve progression of a transfer function a method for estimating a minimum sales increase is thus integrated into the LIS [5], [6].In addition to the transfer function, further interactions are modeled between the different driver parameters. At the same time, the sales volume directly influences the costs of material. In this case, the costs of material increase linearly with the sales volume. Furthermore, the sales volume is limited by the available machinery capacities (reduced by setup times and downtime), which in turn is subject to limited by the size of plants. Due to longer setup times, capacities need to be increased using dispositive measures such as harmonizing work content as depicted with the Production Operating Curves in Fig. 2 [3]. These examples illustrate the complex interactions.

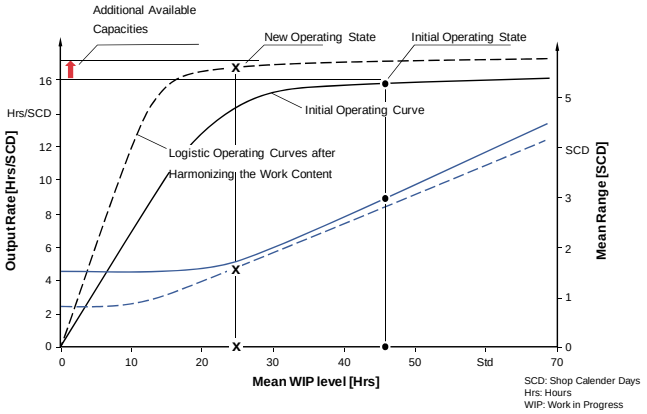


Fig. 2 Logistic Operating Curves according to Nyhuis [1]

The correlations described above are modeled by means of the Logistic Operating Curves, which are also integrated into the LIS. Based on the entered feedback data (input/output dates and work content), the effects of the logistic objectives, e.g. schedule reliability, can be quantified. Hence, the improved schedule reliability is indirectly integrated into the RG through the use of the delivery/sales performance function [8], [9]; the WIP level however is directly incorporated via the costs for the tied-up capital. Moreover, the driver parameters in the LIS influence the location of the Logistic Operation Curves. By increasing the number of machines – and thus increasing capacities – the Output Rate and Range Operating Curves shift [3].Within the context of the subproject C2 "Logistic Operating Curves" of the SFB 489, the LIS was aligned with a rigidly linked forging line, thus preventing it from being adjusted to any other type of manufacturing. In doing so, measures that have different effects on the logistics and monetary key figures and are specific to forging, were stored in the LIS. Included among these measures is the harmonization of work content described above as well as reinforcing a forging machine's die [6].

III. Procedure for Universally Modelling a Decision Model

The research requirements for a universal model that will evaluate logistic measures were derived from the preliminary work of the SFB and applied for within the context of a transfer project. The aim of the project is to transfer SFB 489's knowledge, which is specific to forging, to a universal method, hence making it useful to other sectors. The procedure for this transfer project is depicted in Fig. 3.

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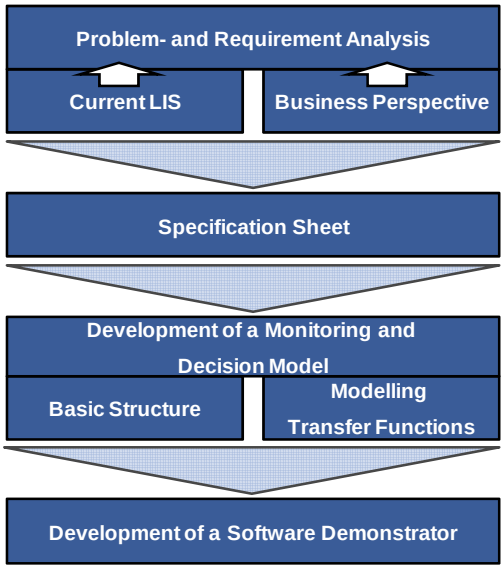


Fig. 3 Depiction of the Procedure for the Transfer Project

At the beginning of the research project and with the assistance of descriptive analyses, requirements for, and difficulties with realizing a universal method for evaluating measures in the production with regard to their impact on logistic and monetary objectives are systematically compiled. In addition to a major review of professional literature with an international scope and a focus on the current status of research, expert consultations on the shop floor are carried out in the form of interviews and workshops. In doing so, one of the aims is to compile the major factors that enterprises observe in the present and future market environment so that these can be included during the development of the model later on. On the basis of the current LIS' available knowledge specific to forging and the limitations that are connected with it, requirements for, and problems with the development of a universal method are derived at the same time (cf. Fig. 3).Based on a comparison of the compiled requirements and current LIS, comprehensive specifications then need to be developed. In doing so, the focus lies on the applicability and transferability of the new monitoring and decision models as well as the impact models (in particular the transfer functions) as a universal approach. In addition to the question of how available models need to be extended, the research investigates the type of sectors or areas of production beyond the forging industry where the current LIS can be transferred without being extended or only slightly extended. Rigidly linked lines in the forging and automobile industry e.g. show parallels that could, upon close examination, allow the LIS to be used. With regards to the limits of applying the current model, criteria need to be compiled, which for example describe the type of manufacturing or linkage as well as the required amount of feedback data. Since the LIS is based on framework requirements specific to forging, applying it to e.g. a shop fabrication with a high number of variants is limited. Subsequently, the criteria developed are stored in a morphological form. After testing the current approach for transferability and locating the application's limits, identifying the logistic and monetary interactions of measures in production in close collaboration with industry representatives is a necessary key factor for developing a universal model. Particularly important interactions are prioritized in the process and in doing so, available approaches, such as e.g. the sales/delivery performance function need to be examined critically. The availability of data is another important aspect for a universal model. In this context, it is necessary to once again work alongside industry representatives in order to define which enterprise data can be provided. This question directly influences the modeling of the transfer functions and consequently the requirements when compiling the specification sheet. Based on the identified areas of application and limits as well as the conducted expert interviews and review of professional literature, a comprehensive specification sheet for implementing a universal model is then compiled. With the assistance of an analytic-deductive procedure, a universal model is developed in close consultation with the industry partners, and a potential framework is compiled for the newly developing monitoring or decision model. In the process, it may be necessary to adjust the driver tree logic. On the basis of the requirements in the specification sheet and the new framework, a model can subsequently be developed. This model will evaluate universal measures, e.g., a reduction of stock orders or harmonizing work content in view of their impact on logistic objectives (such as schedule reliability or the mean output rate of a workstation). This is already possible today with the stored models in the current LIS for rigidly linked or individual workstations. The theory of Logistic Operating Curves needs to be examined in terms of whether, and if so, how it can be applied to describe other, more complex types of manufacturing. In addition, one of the aims is to universally describe the monetary impact e.g. on the economic objective RG. Consequently, the adjustment and further development of the transfer functions are of particular interest for the modeling. The work so far has demonstrated that several transfer functions (linear function, staircase function) could be stored for different application cases (types of manufacturing and sectors). In the present model, for example, a linear correlation was selected to calculate the interaction between the costs of material and the sales quantity. In contrast to the LIS specific to forging, this transfer function could be modeled in the electronic industry by means of a staircase function as depicted in the example in Fig. 4. Whereas, in selected sectors of the electronic branch a simple increase in the sales volume involves immense costs due to the material shortage of specific metals, the jump discontinuities found in a staircase function could represent these. In other cases, a declining correlation would be a correct assumption for specific sectors.

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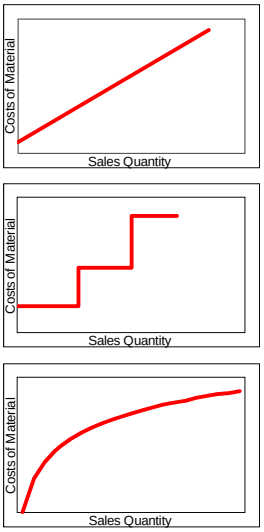


Fig. 4 Correlation between the costs of material and the sales quantity

At the same time, practically implementing the parameterization described earlier on poses a challenge. It has to be ensured that the enterprise's data for the transfer function can be made available in the future as well in order to achieve high quality information.After developing a method for a universal monitoring and decision model, the technical implementation is realized (according to the LIS) with the assistance of a software demonstrator based on VBA in Microsoft Excel©. The use of Microsoft Excel offers some advantages which promote wide acceptance and a high degree of proliferation within and outside the enterprise. Among these is the easy adjustment to changed enterprise requirements. Furthermore, Microsoft Excel is so common in enterprises that the program will not clash with the enterprises' security regulations. Implementations of the newly developed models will be accompanied by industry workshops and expert consultations which discuss the practicability of the software. Aspects, such as user friendliness, will be focused on in these.

IV. Summary and Outlook

The current LIS allows the user to evaluate measures in production by means of logistic and monetary objectives. However, it was only developed for rigidly linked process chains in the forging industry and thus cannot be used across sectors. For this reason, the SFB 489 has applied for a transfer project with the German Research Foundation (DFG) aimed at developing a cross-sector LIS. Requirements for a universal model need to be compiled and interactions in the form of transfer functions tested and refined. The result is a decision support model in the form of a software demonstrator that is applicable across sectors. Ultimately, enterprises with make-to-order productions, serial productions or mixed production should be enabled to logistically and monetarily evaluate defined measures in their productions and, in doing so, reach well-founded investment decisions.

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