Using the ProdFLOW™ Approach to Address the Myth of Productivity in R&D Organizations

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ABSTRACT
Software productivity has been analyzed traditionally in terms of size measures such as LOC or FP. These measures have failed to provide a comprehensive basis for productivity analysis. In the research department of the Siemens AG the new approach ProdFLOW™* for the analysis and management of a research & development organization's productivity is being created based on a revised understanding of the term productivity. Former studies often start with fixed, typical indicators and quantitatively analyze the relation between productivity and the indicator by regression models. ProdFLOW™ departs from the fixed model approach, which might not fit to the conditions of the organization. Instead an organization-specific model based on the substantial levers of the productivity, which are both influenceable and measurable, are compiled together with the experts of the organization. The paper explains the new approach as well as gives an example to illustrate our approach based on the results of three performed case studies.

Categories and Subject Descriptors
D.2.9 [**Software Engineering**]: Management – *Productivity.*

General Terms
Management, Measurement, Economics, Human Factors.

Keywords
Research & Development, productivity measurement, productivity management, model

1. MOTIVATION
Research and Development (R&D) activities are strongly affected by the human factor and dominated by cognitive activities and knowledge work [22], no matter whether its software, hardware or system development.. This is a major difference to the manufacturing business. Usually the input and output of the R&D process differ from one R&D project to another and the R&D process is unique, i.e. not directly and completely repeatable. That means existing approaches of measuring and improving productivity in manufacturing need to be adapted to the characteristics of R&D.

In the research department of the Siemens AG a new approach for the management of productivity in the area of R&D is being created. Former studies often start with fixed models for the productivity and try to calculate quantitatively the relation between productivity and its influencing factors by analyzing regression models. This procedure presupposes that productivity is significantly determined by these influencing factors and that these indicators can easily be changed by the organization. However, we have made the experience that the so-called typical productivity factors are not that typical within SIEMENS. Therefore, we depart from the fixed model approach, which might not fit to the conditions of the organization, and develop a new approach called ProdFLOW™.

The paper briefly motivates our interpretation of productivity in R&D as well as explains ProdFLOW™ approach using an example, which is based on the results of three performed case studies.

2. PRODUCTIVITY IN R&D business
The well-known definition of productivity (relation of output quantity to the input quantity) is often disputed in the world of R&D business. Due to the diversity of disciplines that use the term productivity, there is no clear cut definition of productivity and related terms. This lack of common agreement on what constitutes productivity is perceived as a major obstacle for a substantiated discussion of productivity.

Product management aims to release as early as possible, in order to maximize the relative market value, whereas the product development team wants to maximize the creation of value in the sense of the fulfillment of all customer requirements [3, 5]. The motto "deliver value in time" motivates effective (value) and efficient (in time) product development.

Thus, we define productivity in R&D as the relation between value creation for the customer (output) and the effective budget for research and development (input):

$$\text{Productivity} = \frac{\text{R\&D value creation}}{\text{Effective R\&D budget}}$$

* ProdFLOW is a registered Trademark of the Siemens AG.

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Productivity increases if more or better products are developed from the same resources. Better products may be products of higher quality, higher reliability or flexible products (=higher value for the customer) and thus the created value (for the customer) rises. If we develop the same products with fewer resources, productivity may also increase.

3. OUR APPROACH ProdFLOW™

ProdFLOW™ stands for "Productivity in R&D with FLOW". Especially in the context of knowledge work the status of flow [3] should increase productivity. Within ProdFLOW™ we focus on specific levers when improving productivity in terms of increased value creation and emphasize this using the abbreviation FLOW, which stands for "Focus on Levers to optimize your Work".

The procedure can be applied both to small and large R&D organizations and is also scalable to single phases of the development process. Important is, that the results are developed individually for the evaluated organization and is thus not transferable to other organizations. The aspect of comparability is excluded from this approach, because we consider it more important to improve individual performance than to compare it.

The ProdFLOW™ approach uses our interpretation of productivity in R&D (ratio between value creation for the customer and the effective R&D budget) and aims to cooperatively develop an organization-specific model of the most important productivity levers. This is supported by a systematic procedure explained below.

We split up the approach into four substantial steps and the preparation step 0 "Customize Analysis"; those steps, if necessary, can be iterated several times. The main objective is to improve the identified, major/top levers and to lift these into a balanced condition. In the following the individual steps of our approach are described in detail with the respective activities, tasks and results.

To demonstrate the approach, an example is created for this paper, which is based on the results of three case studies. The case studies were performed to validate the approach.

3.1 Step 0 – Customize Analysis

Step 0 of our procedure has the objective to prepare and plan the subsequent steps. Therefore, the basic goals & characteristics, economic data and future strategic plans of the organization are analyzed. A stakeholder diagram is elaborated to get indications for potential areas of major productivity levers by understanding the network of internal & external stakeholders and their expectations, impacts, cooperation as well as priorities.

3.2 Step 1 – Identify productivity levers

Step 1 of our procedure has the objective to identify and define the substantial levers with influence on the productivity. We focus first on the internal view of the development organization. Additional interviews with a selection of customers of the development organization in order include the external view are valuable.

For the collection of data we decided in favor of the individual interview. We use an interview guideline for the preparation of the interviews and as a starting point into the productivity analysis. The interview itself is an open but guided conversation with the focus on value creation for the customer and its influences. Important is also to query facts and no opinions or rumors.

In the follow-up to the interview, minutes with the major information of the interview are elaborated, i.e. the logging represents an interpretation, which means it is tried to extract the meaning from the recorded spoken words. After the logging minutes are provided to the interview partner for authorization. That gives the evaluation the guarantee that every analysis is based on the right facts. This procedure is based on the work of [5].

Finally a list with levers and their definition based on the aggregated results of the analysis is created. This final activity is critical based on our experience, since the definition of the levers must be formulated objectively and be generally understandable.

The example case study delivered the following list of productivity levers:

L1: Work flow disturbances and multitasking.
L2: Peer-Communication
L3: Documentation and retrieval of knowledge:
L4: Requirements Stability: The number of requirements changes.
L5: Turnover: The amount of change in personnel.
L6: Team Cohesion: The cooperativeness of the stakeholders.
L7: Completeness of Design.
L8: Clear goals.
L9: Information Flow.

3.3 Step 2 – Rank and Filter levers

Step 2 has the objective to rank the identified levers regarding the criteria importance and improvement potential as well as to filter the levers according to the criteria measurability and influenceability.

The results are collected, cumulated and evaluated in the sense of an average ranking, i.e. average rank and the standard deviation for each lever are calculated. In the case of high standard deviation, i.e. very different opinions, the results must be discussed in a group to be clarified.

The results are visualized in a so-called prioritization matrix (2x2-matrix, see Fig. 1) to present the ranking. The two dimensions of the matrix represent (a) the importance of the lever and (b) it's improvement potential. Levers, which are regarded as important as well as having high potential for improvement, are located in the matrix in the upper right quadrant.

Fig. 1 shows example results of prioritization of the example levers. It can be seen that lever L3 (Documentation and retrieval of knowledge) is regarded as very important for the value creation in general but in addition it has a very high potential in the organization, that still has to be leveraged. On the other hand lever L8 (Clear goals) seems to be important but shows a low improvement potential.

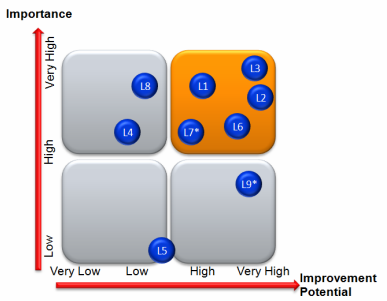

Figure 1: Result of the prioritization

In a further step the levers with high priority are filtered regarding to the criteria measurability and influenceability. Levers, which cannot be influenced by the organization or cannot be measured, will be marked with an asterisk and not further considered in the next steps of the approach.

In our example case study the following three top levers have been identified: L1: Work flow disturbances, L2: Peer-Communication, L3: Documentation and Retrieval of Knowledge

3.4 Step 3 – Define lever indicators and initiate improvement

Step 3 has the objective, to evaluate and measure the identified top levers and to initiate a coordinated productivity improvement project. This is focused on the top levers that considerably affect productivity.

To determine suitable measurement or evaluation instruments measurement expertise is required. The identified levers usually are not standard factors that can be looked up in some reference textbooks. In case of hard factors similar factors can be found in the literature and adapted to the available measuring instrument of the organization. With soft factors suitable inquiries based on a well defined ordinal scale have to be defined, which evaluate the current condition of the factor as objectively as possible.

In parallel to the definition of the measurement and evaluation instruments, the organization has to define measures to improve the levers. This can include a first estimation of the current status of the lever based on the defined measurement instruments.

3.5 Step 4 – Measure levers and determine balance

Step 4 has the objective to track the progress of the productivity improvement project as well as to analyze the balance of levers. The balance is the precondition for the increased value creation at the customer and the related increased productivity.

The idea of balance in the context of ProdFLOW™ is a new concept which tries to analyze and understand the dependencies and influences of the productivity levers on each other as well as on the productivity itself. The idea is in line with the concepts of Pareto optimality or Pareto efficiency: An economic system that is Pareto efficient implies that no individual (lever) can be made better off without another being made worse off [2]. Within our approach it means, that there is no reason to improve one single lever if another important lever may deteriorate.

Due to the fact, that the levers may have a mutual influence the direction (positive, negative) as well as the intensity (high, medium and low) of the influence has to be analyzed. How exactly the balance of the factors is analyzed needs to be further evaluated and validated. It requires further research based on case studies and time for regular data measurement.

There are several potential approaches for analyzing the mutual influence of the levers. We currently focus on Bayesian Belief networks (BBN) [18]. In our BBN the nodes represent the levers as well as the output variable value creation and the arcs represent the causal/influential relationships (see Fig. 2). It visualizes the BBN of our example. A baseline as well as two scenarios are modeled in the BBN.

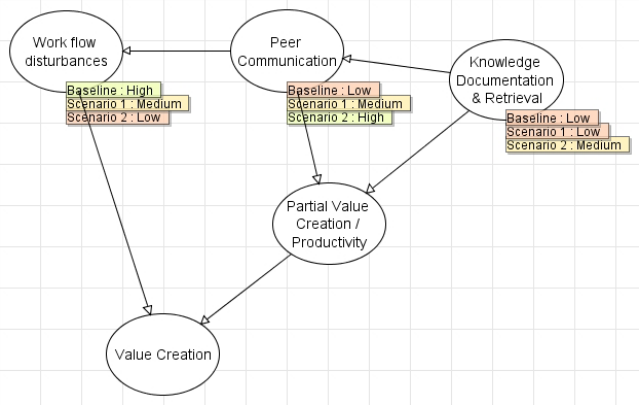

Figure 2: Dependencies between example levers and value creation

One of the advantages of BBNs is their ability to cope with different units and scales as well as being able to model uncertainty. Stamelos et al. [6] propose the use of Bayesian belief networks (BBNs) to support expert judgment in software cost estimation and for productivity estimation.

4. SUMMARY AND OUTLOOK

Productivity is a strategic indicator in manufacturing as well as in engineering organizations, which has to be managed and improved. Based on the differences between manufacturing and engineering the common definition of productivity cannot be transferred to R&D without adaptations for various reasons.

Our approach ProdFLOW™ defines a systematic procedure to improve productivity in R&D organizations. The key element is on one hand the identification of the major levers, that influence the productivity, and on the other hand the measurement, improvement, and balance of these levers.

Recent case studies validated the ProdFLOW™ approach and proved its concepts. Steps 0, 1, 2 and 3 are well established and less critical. The main issue is the valid determination of the balance between the levers in step 4. We need further data and experiences to validate the BBNs.

Since value creation is hard to measure itself for an R&D organization we suggest putting further effort in researching how to define and measure the value of a potential product and/or solution apart from its pure economical value.

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