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# Operational planning level of development in production enterprises in the machine building industry and its impact on the effectiveness of production

Željko Mateljak[a] and Damir Mihanović[b]

[a]Faculty of Economics Split, University of Split, Split, Croatia; [b]Board of Directors, Croatia Health Insurance, Zagreb, Croatia

**ABSTRACT**

This article examines the interdependence between the operational planning level of development and the effectiveness of the production process. The operational planning level of development has been measured by the scale of six intensity levels (1–6) to evaluate each of the eight targeted tasks (planning raw and materials, work planning, planning tools and equipment, capacity planning, termination of production, scheduling by work centres, drafting and launching of work documentation and various records terms and performance), while the effectiveness of the production process has been measured by the following indicators: productivity, stock turnover rate, capacity utilisation rate, delivery time and fallout ratio. The results have shown that enterprises with higher operational planning level of development present better effectiveness of the production process in comparison to enterprises with less operational planning level of development.

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## 1. Introduction

The operational level of planning is primarily realised for specific procedures and processes, and controlled by the lowest ranked managers (Buble, 2000, 2003; Buble, 2006). The lowest ranked managers (in defining operational objectives and plans) are entrusted with operational planning due to the fact that they understand best not only current problems, but also daily tasks and activities to be undertaken (Mihanović, 2016; Sikavica, Bahtijarević-Šiber, & Pološki-Vokić, 2008). This level of planning defines individual tasks to be performed in due time using the available resources. Operational planning comprises a one-year period, it is derived from tactical planning, it contributes to realisation of the planned strategy, it is more detailed and more concrete, and is performed continuously (minimally) at the level of business units, including the production process as well (Bahtijarević-Šiber & Sikavica, 2001; Certo & Certo, 2006; Osmanagić-Bedenik, 2002).

**CONTACT** Željko Mateljak zeljko.mateljak@efst.hr

Operational planning comprises planning of production programme with regard to the type, quantities and sequence (capacity planning), as well as the production sequence planning (working stoke and capacity performance) (Greasley, 2008). Operational production planning, furthermore, determines the machine operation performance time, possible delays and machine alteration time in production process, as well as the execution phases of the production process (Sule, 2008). Besides, the basic production task is related to planning and monitoring the engagement of capacities aiming at predicting whether it is possible to perform a task in given terms and quantities (Jozefowska & Ziminiak, 2008; Žugaj, Šehanović, & Cingula, 2004). Operational planning platform relates to the work preparation for technological work units within a company. Operational planning in production enterprises, in the majority of cases, is very complex (Noori & Radford, 1995). For the successful performance, it is necessary to determine the type of production, aiming at choosing the most favourable method of drafting the operational plan. This is mainly due to the fact that all types of operational plan drafting cannot be applied to all types of production. It appears necessary to precise thereupon the instruments of operational planning in order to secure the planning standards and performance monitoring (Schonberger & Knod, 1994). Well applied operational production planning is determined by a detailed timetable (Mikac & Ljubetić, 2009; Verderame & Floudas, 2008) related to:

- operations, sections and products to be realised within a certain framework and time schedule,
- operations to be realised in each work unit, determination of operational sequences and patterns, and determination of their duration.

Operational planning of production is determined by single production and operation time framework at daily or hourly basis, which relates to different plants or plant units, with regard to the quantity of data the enterprise disposes with at operational level (D'Amours, Rönnqvist, & Weintraub, 2008; Stevenson, 2009). Most frequently, time framework referred to in operational production planning, is a month. Within that time, the realisation and appreciation of the targeted objective must be assured, e.g. timely production of quality products for the requested quantities at minimum cost (Cigula et al., 2002).

Since the industry types are diversified by the production flow or rather, by the type and the company production methodology, the way of implementation of operational planning is specific for each industry. With regard to the fact that the quality of operational plan performance is determined by both execution and effectiveness of the production process, this research aims to determine the operational planning level of development and its impact on better effectiveness of the production process.

Aiming at obtaining the adequate answer to the problem considered, this article defines the basic research hypothesis investigation:

**Hypothesis 1.** *Higher- operational planning level of development affects better effectiveness of the production process.*

The aforementioned research on interdependency has been conducted upon presentation of a questionnaire presented to medium and large enterprises in the machine building industry. The operational planning level of development has been evaluated by planning raw and materials, work planning, planning tools and equipment, capacity planning, termination of production, scheduling by work centres, drafting and launching of work documentation and

various records terms and performance. Each task states different lemmas to be evaluated by a six-intensity-unit-scale (1–6), whereas the production process effectiveness has been measured by the following indicators: productivity, stock turnover rate, capacity utilisation rate, delivery time and fallout ratio.

Besides determining the interrelation between the operational planning level of development and effectiveness of the production process, the goal of this article is to achieve the following objectives:

- to determine the basic implementation goals in operational planning,
- to determine the most frequent problems in operational planning,
- to determine operational planning levels of development between medium and large companies in the machine building industry,
- to determine how operational planning levels of development effects on effectiveness of the production process, and
- to determine most important factor that limits improvement indicators effectiveness of the production process, such as productivity, stock turnover rate, delivery time and fallout ratio.

Good implementation of the process of operational planning is essential for the successful realisation of the production process. Since the implementation quality of operational planning depends on the level of task elaboration, the research survey in the field of operational planning and its impact on the effectiveness of the production process, is presented in the next section.

## 2. Theoretical background

A significant number of papers have taken into consideration the impact of production planning on effectiveness of an enterprise. Some of the research has examined the impact of elements of the planning scheme (aggregate planning, business scheme, aggregate production scheme, demand management, resources and capacity planning) and production control (forecasting control, procurement and control of materials and monitoring of production activities) onto the effectiveness of the production process (timely delivery, fallout ratio, equipment utilisation and productivity) (Wacker & Sheu, 2006). The research has been conducted in machine building and textile industry, on 768 production units in 16 countries. The results of the research have shown that all the elements of planning schemes have impacts on the increase of equipment utilisation and productivity. Within the production control system, the procurement control impacts the increase of equipment utilisation and productivity, and production monitoring rationalises the utilisation of equipment and productivity. As regards the impact on timely delivery and fallout ratio, all elements of the planning scheme and production control impact the reduction of fallout ratio and realisation of the estimated times of delivery.

There is, furthermore, one research dealing with the impact of production plan elaboration level (strategic business plan, sales plan, operational plan, main production plan, materials projection and monitoring and procurement plan) onto the effectiveness of the production process (delivery time). The research was conducted at Motorola in 2005, from January to March. The results of the research show that better elaboration of the production plan affects low divergences in terms of product delivery. For example, high production

plan elaboration level can influence the time of product delivery to be 60–66 days (Chen & Cochran, 2005).

Some of the research in this area considered the impact of effective spatial equipment disposition scheme factors (flexibility and utilisation of production equipment) on productivity. The research has used a model comprising two factors: flexible spatial equipment disposition scheme and utilisation of production equipment. The results of the research have shown that the increase in flexibility and utilisation of the production equipment affect the cost reduction of materials for 10–30%, thus increasing the productivity of the enterprise (Raman, Nagalingman, & Lin, 2008).

Furthermore, in 1995, Meybodi (Meybodi, 1995) conducted the research in which the outcomes of the existent Hierarchical Planning Production (HPP) model (aggregate planning, disaggregated group decision planning, termination, evaluation of the production plan) were compared by using linear programming aiming at minimisation of costs: stock declaration, replacement of materials, subcontracting and labour force. The success ratio was measured by capacity utilisation and general business costs indexes. The results of this research show that the implementation of the existing HPP model, in comparison to the new one, implicated the increase in overall business costs for 9.1%. When high error forecasting that characterises the HPP model is included at the same level, then the existing HPP model, when compared to the new one, presents the overall costs increased for 12.6%. As regards the capacity utilisation, the comparison was made in terms of limited capacities. In such terms, new HPP model has better capacity utilisation then the existing model, due to the fact that in conditions of the limited capacity, the existing HPP model presents overall costs increased for 38.3%.

There is also one interesting research which takes in examination the most frequent limiting factors of success/failure of integration of business processes: planning, termination and control. This research has been conducted in the process industry (chemical, refineries), and results have shown that the following are the success/failure factors: management model, type of organisation structure, organisation and human behaviour and training and retaining of highly qualified personnel. Management model is, for instance, the limiting factor in chemical industry due to high level of decentralisation, whereas the organisation scheme is a limiting factor in refineries due to lower flexibility rate (Shobrys & White, 2002).

Research conducted in the field of operational planning are related to different business aspects. One research is thus oriented towards identifying factors of successful Sales & Operational Planning (S&OP) integration in management of production enterprises. The research has been conducted in electrical and furniture industry in 15 production units. The results have shown that the precondition for successful integration of the S&OP concept in production enterprises' management lies in harmonisation of the following five phases: sales planning, stock level declaration, development of final operational plan, plan implementation and measurement of S&OP concept effectiveness. However, in this research, the emphasis has been put on integrating sales to operational planning, which is perceived as the platform for the successful S&OP integration, regardless the harmonisation of other phases in the existing concept. It is perceived as the prerequisite for optimal profit level (Grimpson & Pyke, 2007).

The next research was oriented to examining the impact of tools' planning, as a part of operational planning, on success of production system in general (flexibility, equipment utilisation and productivity) by using the Tool Loading and Routing Model (TLRM). The

results of the research have shown that both the unavailability of tools resulting in slowing the rotation of materials in production process, and extension of intervals in processing of materials and intermediate goods, along with frequent changing in position of tools' position, delay the production cycle. The inadequate tool planning, with low capacity utilisation and unacceptable time loss ratio, lead to reduction of productivity of the enterprise (Mohamed & Bernardo, 1997).

Another research could be added to the aforementioned. It examines the length of operational planning time horizon and how it could impact the number of machine schedule shifts. The research has been conducted during the production process in Westinghouse factory on 103 samples. The results show that operational planning time horizon affects the machine schedule shifts. For instance, the production system with shorter time horizon (0–4 months) is very sensitive to waiting intervals and causes a significant number of shifts in machine settings. On the other hand, the production system with longer time horizon (4–10 months) causes lower number of shifts in machine settings, which leads to shorter waiting intervals (De & May, 1998).

Except for production process effectiveness, it appears necessary to mention research taking in consideration relations between operational production planning and type of production process, following the products' sequence. Gaskill and others (Gaskill et al., 1996) identify the relevance of operational planning in small enterprises. The authors list factors influencing the efficient implementation of operational planning. Among others, the factors are represented by the workers' inexperience, minimum knowledge in planning process, lack of confidence, and insufficient sincerity between employees. They also evidence the tendency of small enterprises to avoid planning, because they do not supply large markets and they do not produce complex products as do the large enterprises. Pursuant to this, they conclude that strategic planning is much more useful for small businesses than operational planning itself.

Shrader et al. (1989), on the other hand, conclude that top management in small enterprises must be focused on operational planning, in particular to daily based time planning. They, furthermore, list positive correlations between operational planning and performances in small enterprises, whereas in large enterprises there are positive correlations between performances and strategic planning. They consider the promotion of operational planning effectiveness to be the key success factor in small enterprises. It must, however be stressed that small enterprises prefer operational planning to strategic planning.

As regards the interrelations between operational production planning and type of production process, according to Yang and Chen (Yang & Chen, 2007), the implementation of operational production planning procedure in some enterprises is achieved in easier and in others in a more difficult way. In the majority of enterprises with assembly line production type, the same product constantly passes through same working posts with capacities harmonised reciprocally. In an enterprise with the assembly line production process type, it is enough to determine the rhythm of material inflow into the first processing phase, and the rhythm of outflow of final product from the final phase. The planning is much more complex in project type production process. In long run, it is difficult to specify what types of jobs are going to be performed at single posts, because, there is either no specification of products to be processed, or the processing sequence and the duration of operations are unknown. Operational production planning in a serial production type and instruments necessary for the implementation of operational planning can be used both for operational

production planning in assembly line and single production process. Very important in operational production planning in a serial production type is planning of time framework, which does not comprise a period of a month, but a period of a fortnight, or even 10 days, because the capacities of all working posts are neither coordinated, nor is the production rhythm, typical for line production process, standardised.

After the short survey of research performed in the field of operational planning, in further text follows the presentation of results of our investigation, along with the presentation of the impact of the operational planning level of development into the effectiveness of the production process.

## 3. Methodology of empirical research

Pursuant to the National classification framework there are 70 large and medium enterprises in the Republic of Croatia in the machine building industry. They have all been included in the empirical research for the purposes of this article. The questionnaires were sent to the CEOs or production managers. Of 70 questionnaires, 48 were fully responded to. The return rate was 68.57%.

The research time was conducted in the period between June and October 2011. The questionnaire consisted of the following three sections:

- The first section was aimed at collecting basic information on the enterprise, such as: company size and type of production process.
- The second section of the questionnaire was aimed at collecting information regarding the operational planning level of development which contained various statements comprised in eight preparatory tasks. Each statement was evaluated on the scale of six intensity levels (1 = I fully disagree; 2 = I partially disagree; 3 = I disagree; 4 = I partially agree; 5 = I agree; 6 = I fully agree). Besides the aforementioned, this section determined the basic objective of operational planning implementation and identified problems to be faced by enterprises in operational planning.
- The third section of the questionnaire aimed at determining the level of effectiveness of the production process, and contained analyses of factors that affect productivity, stock turnover rate, capacity utilisation rate, delivery time and fallout ratio.

The collected data were processed using the statistical package SPSS 17.0. The methods used there upon were the following:

- Descriptive statistics to describe variables such as: company size, type of production process, operational planning implementation goals and problems in operational planning,
- Mean values to calculate the total average grade of operational planning in a single enterprise,
- Cluster analyses (hierarchical cluster analyses, Euclidean distance, and standardised probability values of the variables by using the z coefficient) to determine the lower and higher operational planning level of development,
- Analysis of variance to examine the interrelation between the operational planning of development and productivity, stock turnover rate, capacity utilisation rate, delivery time and fallout ratio,

- Multiple regression to examine the interrelation between the operational planning level of development and effectiveness of the production process.

The recovered data were used to prove or reject the basic hypothesis of this article.

## 4. Empirical results

### 4.1. Targeted enterprises – basic data

As we have previously mentioned, this research was conducted in machine building enterprises. The questionnaire was sent to 70 enterprises and 48 fully completed it. This research is based on the data collected. There follows a survey of basic company data, such as: size (per number of employees) and the type of production process, which is followed by the presentation of research results.

First analysed index was the *company size* with regard to the number of employees. Regarding that criterion, there are three company types in the Republic of Croatia: small, medium and large. This research takes in consideration medium (50–249 employees) and large companies (250 employees and more), whereas their proportion is shown in Table 1.

Table 1 shows that there were 27 (56.3%) medium, and 21 (43.7%) large enterprises, and that medium enterprises are more largely represented.

As regards the production process type, there are three types: line, interrupted and project. Table 2 shows types of the production process employed in targeted companies.

The results in Table 2 show that the lowest number of companies (9 or 18.8%) use the line production process type, whereas the majority of companies (22 or 45.8%) use the interrupted production process type. As opposed to them, 17 companies or 35.4% employ the project production process type.

The implementation of process planning is motivated by achievement of objectives like: minimisation of production time flow, capital lock-up, cost of equipment, transport costs, observation of terms of production and optimisation of capacity utilisation. Table 3 shows the desired objectives to be achieved by the targeted companies.

The results in Table 3 show that targeted companies in the machine building industry do not consider the minimisation of cost of equipment and cost of transport to be the main goals of operational planning. The majority of companies (56.3%) consider the compliance with the terms of production to be the basic goal of operational planning, whereas 22.9% of the companies consider the optimisation of capacity utilisation as their primary objective. Only 16.7% of the companies consider the minimisation of production time flow their main objective.

The examinees were also asked to list the problems they affect on an operational planning level of development. Forty-three of 48 examinees provided an answer to this question. Their statements are listed in Table 4.

**Table 1.** Company size in the machine building industry.

| Company size | No. of companies | Percentage (%) |
|---|---|---|
| Medium enterprises (50–249) | 27 | 56.3 |
| Large enterprises (250 and more) | 21 | 43.7 |
| Total | 48 | 100 |

Source: Authors.

**Table 2.** Companies per production process type.

| Production process type | No. of companies | Percentage (%) |
|---|---|---|
| Line production process type | 9 | 18.8 |
| Interrupted production process type | 22 | 45.8 |
| Project production process | 17 | 35.4 |
| Total | 48 | 100 |

Source: Authors.

**Table 3.** Operational planning implementation goals.

| Goals | No. of companies | Percentage (%) |
|---|---|---|
| Minimisation of production time flow | 8 | 16.7 |
| Minimisation of capital lock-up | 2 | 4.2 |
| Observation of terms of production | 27 | 56.3 |
| Optimisation of capacity utilisation | 11 | 22.9 |
| Minimisation of cost of equipment | 0 | 0 |
| Minimisation of transport costs | 0 | 0 |
| Total | 48 | 100 |

Source: Authors.

**Table 4.** Problems in operational planning level of development.

| Problems in operational planning level of development | No. of companies | Percentage (%) |
|---|---|---|
| Special product performance | 2 | 4.2 |
| Technological support to planning | 3 | 6.3 |
| Delay in delivery of materials and absence of workers | 6 | 12.5 |
| Lack of quality personnel in field of operational planning | 4 | 8.3 |
| Oscillations in sales planning | 3 | 6.3 |
| Unforeseen event (error report in planning) | 1 | 2.1 |
| Poorly drafted documentation | 2 | 4.2 |
| Modification of client's request | 4 | 8.3 |
| Short time framework between the request and time of delivery | 7 | 14.6 |
| Equipment malfunction | 3 | 6.3 |
| Delay of documentation | 6 | 12.5 |
| Lack of capacities | 1 | 2.1 |
| Insufficient cooperation in planning between individuals and department | 1 | 2.1 |
| Total | 43 | 100 |

Source: Authors.

As shown in Table 4, the majority of companies (7 or 14.6%) report short time frameworks between the presentation of a request and time of delivery, to be the key problem. This means that customers, at the moment of contracting and in defining delivery time, request fast delivery. It causes certain changes in the existent production termination cycle. Companies can solve this problem by applying the urgency rule. According to that rule, the first to be terminated, are orders with shorter terms of delivery or, if received subsequently, they replace orders with longer terms of delivery. In such a way, the full compliance with the accepted terms of delivery is assured. Besides the aforementioned, six companies or 12.5% face problems with the delay of materials, absence of workers, and delay in presentation of documentation. These problems in operational planning cause delays, standstills, waiting, and prolongation of production time cycle, and it automatically leads to the inobservance of terms of delivery, low productivity, low level of capacity utilisation, low stock turnover coefficient and high lock-ups.

### 4.2. Operational planning level of development affect the effectiveness of the production process – analysis

This chapter brings the analyses of the operational planning level of development, upon determining the preparatory tasks' average grades, such as: planning raw and materials, work planning, planning tools and equipment, capacity planning, termination of production, scheduling by work centres, drafting and launching of work documentation and various records terms and performance. Three to four assertions were offered for each task. It is possible to obtain significant results in this article only using the previously mentioned eight targeted tasks. Same tasks are very important for measurement of the operational planning levels of development because without same would not be able realisation of production process. Therefore, all the eight targeted tasks are very important to the clustering of the two groups of operational levels of development. The average grade, both for assertions and for each task in general, was derived after its evaluation. The average task grades were used as the platform to determine the operational planning level of development. The assumption was made that the companies, whose average grades in preparatory tasks were lower than 3, did not develop their operational planning, because the examinees did not agree with the assertions. On the other hand, for the companies whose average grades in preparatory tasks were higher than 3, it was indicated that they showed a certain degree of development of operational planning, because the examinees partially agreed with the proposed assertions. The processing of the acquired data showed that average grades for the preparatory tasks were higher than 3.

Since all the participants evaluated the preparatory task implementation level with the grade higher than 3, the classification was made as per lower and higher operational planning level of development. The cluster analysis, derived from the Ward methodology, was used for the purpose. Some sub-methods were used as well, like: hierarchical cluster analyses, Euclidean distance and standardised variable value by using z - coefficient. The results of the cluster analyses are shown in Table 5.

As shown in Table 5, the average grades for each preparatory task with lower operational planning level of development are lower than the average grades for the same tasks with higher operational planning level of development. The classification per level of development, performed pursuant to the said grades, is shown in Table 6.

As shown in Table 6, lower operational planning level of development was detected in 18 companies or 37.5%, while better operational planning level of development, was detected in 27 companies or 56.3%. Forty-five companies were submitted to the classification

**Table 5.** Preparatory tasks per lower and higher operational planning level of development.

| | Operational planning level of development | |
|---|---|---|
| Preparatory tasks | Lower | Higher |
| Planning raw and materials | 4.03 | 5.12 |
| Work planning | 4.08 | 5.19 |
| Planning tools and equipment | 4.15 | 5.15 |
| Capacity planning | 4.14 | 5.31 |
| Termination of production | 3.78 | 5.05 |
| Scheduling by work centres | 3.61 | 4.88 |
| Drafting and launching of work documentation | 3.80 | 5.16 |
| Various records terms and performance | 3.96 | 5.19 |

Source: Authors.

**Table 6.** Companies per higher and lower operational planning level of development.

| Operational planning level of development | No. of companies | Percentage (%) |
|---|---|---|
| Lower | 18 | 37.5 |
| Higher | 27 | 56.3 |
| Total | 45 | 93.8 |

Source: Authors.

procedure, whereas three companies (6.2%) were left out due to the inability to calculate the total average grades of the preparatory tasks.

Subsequently to the classification of companies per higher or lower operational planning level of development, the interdependence between the operational planning level of development and effectiveness of the production procedure was examined. In testing the hypothesis, it was assumed that companies with more efficient operational planning were able to generate better effectiveness in production process than companies with lower operational planning level of development, e.g. it was assumed that they generated higher productivity, presented higher stock turnover rates, higher level of capacity utilisation rate, realise faster terms of delivery and have lower fallout rates. Further, testing the hypothesis in this article can use the analysis of variance and regression analysis and since they yield the same results, the authors decided to use analysis of variance.

#### *4.2.1. Impact operational planning level of development on productivity*

The objective, to determine whether companies with more efficient operational planning realise higher productivity than companies with less efficient operational planning, was reached by investigating the impact of operational planning level of development on productivity. The value indexes: general revenue ratio (UP) and employee ratio (R) were used to calculate the productivity level. The results of the research are shown in Table 7.

As shown in Table 7, companies with less efficient operational planning generate lower average productivity per employee (420,985,46 Croatian Kunas), whereas companies with more efficient operational planning generate higher average productivity per employee (669,617,53 Croatian Kunas). The difference in the realised productivity of the analysed companies is statistically significant ($p = 0.100$; $df = 43$), showing that companies with less efficient operational planning have lower productivity and vice versa.

The company productivity is often influenced by various factors, in particular those that directly impact the level of the generated revenue and quality of employees. From given results the investigation can conclude that the majority of companies (18 or 39.13%) indicated the obsolescence of the equipment to be the most significant constraint factor in limiting the productivity. It can be deduced that, there is still a rather high number of companies with obsolete technological equipment that cannot match the equipment of globally relevant companies in the same production line. Both frequent defects, higher

**Table 7.** Average productivity and operational planning level of development.

| Average productivity (kn) | | | |
|---|---|---|---|
| Lower level | Higher level | Significance (ANOVA) | Degrees of Freedom (df) |
| 420,985,46 | 669,617,53 | 0.100* | 43 |

*Test significance level 0.1.
Source: Authors.

**Table 8.** Stock turnover coefficient and operational planning level of development.

| Average stock turnover rate coefficient | | | |
|---|---|---|---|
| Lower level | Higher level | Significance (ANOVA) | Degrees of Freedom (df) |
| 5.8 | 5.8 | 0.994 | 44 |

Source: Authors.

maintenance costs, standstills in production process, or downgraded utilisation potential of production equipment, can be the consequence of this obsolescence, lowering thus the productivity and causing falls in the competitive strength.

### *4.2.2. Impact operational planning level of development on stock turnover rate*

The coefficient of stock turnover rate was the second indicator aimed at examining the effectiveness of production process. This indicator was used to determine the turnover rate per calendar year, and is derived by calculating total revenue and stock quantity. The results are shown in Table 8.

The results shown in Table 8 indicate values of stock turnover rate coefficient to be identical both in companies with higher (5.8) and lower (5.8) operational planning level of development. There emerges a rather logic test result, to which there is no statistically significant difference ($p = 0.994$; $df = 44$) between the stock turnover coefficient and operational planning level of development. Reasons for this given result is that most investigated companies have a long production cycle, keeping highly expensive merchandise in stock for long time and poor quality of stocks.

From the given results investigation it can be concluded that is *the long production cycle* factor which most limits the stock turnover rate coefficient by largest number of companies (23 or 54.76%). This shows that a large number of companies face different types of standstills, which makes the real cycle significantly longer than the theoretical one. The reasons to this may be related to different problems with materials, suppliers, machinery, termination period, labour scheme, etc.

### *4.2.3. Impact operational planning level of development on capacity utilisation rate*

The capacity utilisation rate shows the intensity of utilisation of working tools, as well as the duration of utilisation time of machines. The higher the capacity utilisation rate, the better usage of the production gear is. The results are shown in Table 9.

The results presented in Table 9 show that less efficient operational planning results in lower average capacity utilisation rate (70.59%), as opposed to higher operational planning level of development (79.05%). Although the difference in capacity utilisation rate may not seem high (it is for 8.5% higher in companies with more efficient operational planning), the tests have proved it statistically significant ($p = 0.083$; $df = 41$). It can be concluded that

**Table 9.** Capacity utilisation rate and operational planning level of development.

| Average capacity utilisation rate | | | |
|---|---|---|---|
| Lower rate | Higher rate | Significance (ANOVA) | Degrees of Freedom (df) |
| 70.59% | 79.05% | 0.083* | 41 |

*Test significance level 0.1.
Source: Authors.

**Table 10.** Fallout ratio and operational planning level of development.

| Average rate of fallout ratio | | | |
|---|---|---|---|
| Lower ratio | Higher ratio | Significance (ANOVA) | Degrees of Freedom (df) |
| 4,649% | 1,514% | 0,037** | 34 |

**Test significance level 0.05.
Source: Authors.

companies with more efficient operational planning have better capacity utilisation rate and vice versa.

### *4.2.4. Impact operational planning level of development on fallout ratio*

The fallout ratio is always linked to the quality of a product, as well as to the production costs. Although the intent to reduce the fallout ratio is always present, errors that occur during the production process, may be related to poor maintenance of machines, to selection of substandard materials, work force replacement, and similar reasons. The fallout ratio is used to measure the percentage of products that do not correspond to the requested quality standards.

The collection of data referred to the fallout ratio in the machine building industry, was also conducted after the survey and same ratio was obtained directly from the interviewed persons. The test results of the discrepancies in fallout ratio, are shown in Table 10.

Table 10 shows that companies with less efficient operational planning, realised higher average fallout ratio (4.649%) than companies with higher operational planning level of development (1.514%). The difference is statistically significant ($p = 0.037$; $df = 34$), demonstrating that companies with higher operational planning level of development present lower fallout ratio, whereas companies with less efficient operational planning present higher fallout ratio.

Form given results investigation can conclude that 13 companies (28.89%) consider *the inadequate material and resources* to be the most significant cause of fallout ratio. By defining this factor as the most significant, it is shown that the material and resources represent the key fallout cause in the majority of companies, instead of work force, machines or working methods. It would be very interesting to investigate why material and resources represent the critical factor. The reasons may lie in an unreliable supplier, or in typology of materials and resources (by trying to get the cheapest product, lower quality materials and resources are ordered).

### *4.2.5. Impact operational planning level of development on delivery time*

Delivery time, as the fifth indicator of effectiveness of the production process, shows the percentage of products delivered to the end-user in scheduled time, providing thus the assessment of the company capacity to deliver sooner or later than scheduled or stipulated in the contract.

Similarly, to determine the utilisation capacity and fallout ratio, the interviewed people were asked to provide a direct judgment as to the company compliance with the delivery time. The results of company compliance with the delivery time are shown in Table 11.

**Table 11.** Delivery time and operational planning level of development.

| Average time delivery | | | |
|---|---|---|---|
| Lower level | Higher level | Significance (ANOVA) | Degrees of Freedom (df) |
| 77.93% | 90.27% | 0.001*** | 38 |

***Test significance level 0.01.
Source: Authors.

**Table 12.** Operational planning level of development and effectiveness of production process.

| Multiple regression | |
|---|---|
| Regresand | Operational planning level of development |
| Regressors | Productivity<br>Stock turnover rate<br>Capacity utilisation rate<br>Fallout ratio<br>Delivery time |
| B and t- values | |
| Name of regressors | Value |
| Constant | 2.388**(2.744) |
| Productivity | 0.000000317(1.520) |
| Stock turnover rate | 0.002(0.075) |
| Capacity utilisation rate | 0.00007273(-0.010) |
| Fallout ratio | -0.036(-1.431) |
| Delivery time | 0.027***(2.852) |
| Other values | |
| Coefficient of determination (R) | 0.663 |
| Square number of the coefficient of multiple correlation ($R^2$) | 0.439 |
| F-test Degrees of Freedom (df) | 4.074***31 |

Notes: *t*-values are given in parenthesis.
**Correlation significance level 0.05.
***Correlation significance level 0.01.
Source: Authors.

From the data shown in Table 11, it emerges that companies with lower operational planning level of development (77.93%) present significantly lower compliance with the delivery time than companies with higher operational planning level of development (90.27%).

Although the differences in realised delivery time are visible at first sight, the tests have undisputedly confirmed them as well ($p = 0.001$; $df = 38$).

From given results investigation in Table 11 it can be concluded that the majority of companies (21 or 44.68%) declared the delays in material delivery in processing the most important factor in postponing the delivery time. The delays in delivery of materials in processing could result from delays of suppliers, or failures to deliver timely the resources and materials, but might also indicate problems in the production process itself.

Having tested the interrelation between the operational planning level of development, and individual factors of effectiveness of the production process, the present article took in examination the impact of the operational planning level of development on the overall effectiveness of the production process. Multiple regression, assisted by the enter methodology, was used in testing their interrelation, aiming at verifying if more efficient operational planning implies higher effectiveness of the production process. Test results of this assertion are shown in Table 12.

Table 12 shows that the *basic hypothesis of this research* has been confirmed by proving that the increase in operational planning level of development leads to increase of effectiveness in the production process. Since F-test is statistically significant at 1% significance level.

## 5. Discussion

The results of the present research have proven the basic hypothesis of this article. By using the multiple regression, it has been shown that more efficient operational planning has better impact on effectiveness of the production process. On the other hand, the results of previous research have shown that better elaboration and production planning development, affects the increase of productivity and capacity utilisation; lowers the fallout ratio (Meybodi, 1995; Wacker & Sheu, 2006) and affects the compliance with the terms of delivery (Chen & Cochran, 2005; Mohamed & Bernardo, 1997). The only exception is the stock turnover coefficient, since the results of this article contradict the results of the research by Raman et al. (2008). Therefore, it can be concluded that the majority of the research results presented in this article, are compliant with the results of the aforementioned authors. Except for the basic hypothesis, this article considers the second and the third one, and rejects them both on the ground of obtained results. Upon examination of the second hypothesis, it has been shown that larger companies have not developed operational planning better than the medium ones, which is contrary to the results of the previous research (Gaskill et al., 1996; Shrader et al., 1989). On the other hand, the analyses of results of the third hypothesis, show that companies with more complex production process types do not have better and more efficient operational planning. With regard to this, it can be concluded that there is no coherence between the result itself and the research by Yang and Chen (Yang & Chen, 2007). However, it must be emphasised that the coherence between the basic hypothesis of this article and previous research, point to the quality and credibility of the research.

There have been some limiting factors in the research. Firstly: on collecting and analysing the research results, there have been limitations as to the number of relevant papers in this field. It primarily refers to a relatively small number of papers containing analyses of the interrelation between the operational planning in production and effectiveness of the production process. Secondly: the limiting factor was noted at determining the number of companies available for the research. This means that there were no integrated databases providing information on number of medium and large enterprises in the machine building industry. Instead, the database was created by the authors, requiring thus additional efforts and time. Thirdly: at determining the production process effectiveness, the limiting factor was the lack of indexes of production process effectiveness. They were either calculated and obtained directly, or determined upon filling up the questionnaire by the company, which at the same time provided the income and balance sheets. It again proved the inexistence of the adequate data base in the Republic of Croatia, containing information necessary to conduct relevant research in the machine building industry. Fourthly: the limiting factor was also the inexistence of contact information of directors or production managers in the majority of enterprises comprised in the research. They had to be found, contacted individually and only then the questionnaire could be sent to them via e-mail. It must be emphasised that factors influencing the increase and decrease of productivity, stock turnover coefficient, fallout ratio, were identified in this research, as well as those affecting terms of delivery. The same factors were not identified for the capacity utilisation level, because the targeted

companies did not provide answers to this question in the questionnaire. However, upon insight and research of the relevant scientific bibliographical units and having conducted the research in the field of operational planning in production, it can be concluded that there is still plenty of room for further researches regarding the following:

(A) interrelation between the operational planning and business efficiency of production enterprises. The basic research topic should focus on determining if higher operational planning level of development implies better business efficiency in production companies, and vice versa;
(B) the operational planning level of development can be examined also taking in consideration production process with reference to the production volume (individual, serial and mass production), type of the organisational structure (functional, divisional, matrix process and network) and company size. Should that be the case, the research should focus on determining which production process type, with regard to the production volume and organisational structure, has better operational planning level of development. For example, it is very interesting to investigate relationship between operational planning level of development and size company. Results of investigation, using by Hi-square test or Logistic regression, can show that larger companies can have a better operational planning level of development than medium ones because larger companies produce more complex product via complex production process. This requires detailed elaboration tasks of operational planning and so as to effect better operational planning level of development.
(C) research each and individual preparatory task for production operational planning (Table 7), because they can be considered as separate research topic, and examine their impact on competitiveness and profitability of an enterprise;
(D) examine the impact of the operational planning level of development on production time cycle. This research should focus on determining if enterprises with higher operational planning level of development have shorter production time cycle than enterprises with lower operational planning level of development.

## 6. Conclusion

Planning is defined as the procedure of conducting and implementing specific phases to determine the direction of activities of an enterprise. It is a creative process aiming at predicting the future, and anticipating future opportunities and threats. High quality implementation of specifically planned phases should be consistent, following the model of rational decision making. Since this article focused primarily on operational planning, it considered tasks for the implementation of which operational preparation appeared necessary. Operational planning tasks imply preparatory procedures, aiming at production process realisation. However, operational planning implies various tasks whose implementation depends on its elaboration. The tasks are standardised in the majority of researches. Usually we refer to resource and planning material, capacity and work planning, scheduling by work centres and drafting and launching of work documentation, without the elaboration of which, the efficient operational planning could not be realised.

The successful realisation of the production process, besides depending on the quality implementation of operational planning, depends on quality decision making. Managers'

decisions are brought, in majority of cases, pursuant to the well elaborated production plan (basic or annual, dynamic annual, flexi quarterly, monthly or operational, term or weekly), and are aimed at realising the production goals – timely production of quality products in the desired quantities with minimum costs.

The effectiveness of the production process depends on the operational planning level of development and implies the ability of the production enterprise to realise the set goals. The effectiveness of the production process can be measured by different indexes. The following indexes were used for the purposes of this article: productivity, stock turnover coefficient, capacity utilisation level, fallout ratio and delivery time.

The research conducted for this paper took in consideration the impact of operational planning on effectiveness of the production process in the machine building industry, and was conducted in 70 large and medium enterprises. The output was 68.57%, or 48 production enterprises. The research comprised only medium and large enterprises, because many small enterprises do not employ operational planning, since their organisational scheme is simpler and their work scheme is less complex. Three hypothesis have been set for this research. The results obtained after data processing showed that higher operational planning level of development implied better effectiveness of the production process. This confirmed the basic hypothesis of the paper ($r = 0.663$; $p = 0.007$). Besides the basic interaction, the interrelation between the effectiveness of operational planning and individual effectiveness index of the production process were taken in consideration. The results have shown that there is no statistically significant difference between the operational planning level of development and stock turnover coefficient ($p = 0.994$), while between the operational planning level of development and productivity ($p = 0.100$), capacity utilisation rate, ($p = 0.083$), delivery time ($p = 0.037$) and fallout ratio ($p = 0.001$) there are statistically significant differences. The variance analyses and multiple regression were used in testing the first hypothesis of this article.

Since the obtained results have clearly shown that more efficient operational planning and better elaboration of the preparatory tasks lead to higher effectiveness of the production process, the conclusion has been drawn that both features could serve as the platform for improvement of business activities in production enterprises in any industry with the objective to improve its competitiveness.

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