



The concept of operation and production control

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Abstract

The theoretical aim of the paper is to analyse the main function and concept of production control in operation management. The empirical aim of the paper is to investigate Polish production firm opinion about factors affecting production planning and control and also functions of production planning and control. Production control is very important in every factory, and every aspect of operation and production management especially in times of Industry 4.0 conditions. In the paper we presented all classical seven tasks of production management control. Also there is in the paper an analysis of main factors affecting production control in industrial organization. In the paper we analysed the problems connected with production control. Nowadays in the conditions of Industry 4.0 this is very important concept because the increasing level of digitalization of all industrial processes leads to possibility of detailed analysis of all processes and better level of control. Operation managers should have good level of knowledge about production control and especially quality control. They can use in this many new information tools like statistical methods and artificial intelligence. Especially we think that in the future many functions of production control would be assisted by artificial intelligence. We also in the paper give results of research conducted on example of 30 Polish production organizations located in Silesia region.

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1. Introduction

Production control is very important in every factory, and every aspect of operation and production management especially in times of Industry 4.0 conditions (Wolniak, 2020; Wolniak, et al., 2020; Amjad, et al., 2021; Drozd and Wolniak, 2021; Fromhold-Eisebith et al., 2021). Without proper level of control we cannot achieve the proper level of quality of product and because of that we cannot achieve proper level of fulfillment of customers demand. In times of Industry 4.0 all organization processes are digitalized and can be controlled (Gajdzik and Wolniak, 2021; He et al., 2021; Kadir and Broberg, 2021; Saniuk et al., 2020; Ingaldi and Ulewicz 2020). Production control and its methods vary between particular firms and plants because for now not all organizations have sufficient level of digitalization. The level of digitalization has an important impact on the method used to control the production processes.

In some situation effective production control is possible, and the smooth production results are something possible to behold. But in others cases where the inappropriate methods are used for the production control, it can make the situation

worse (Wilson, 2018; Wolniak et al., 2019; Wolniak, 2019; Johnston, 1994; Jonek-Kowalska, 2019). In practice, the production control department has been changed from the beginning of organized manufacturing system with initiating production orders and scheduling the sequence of tasks, in addition to follow-up tracking (Domingues and Machado, 2017).

The theoretical aim of the paper is to analyse the main function and concept of production control in operation management.

The empirical aim of the paper is to investigate Polish production firm opinion about factors affecting production planning and control and also functions of production planning and control.

We formulated following research questions:

- What is the assessment of Polish production firms of factors affecting production planning and control?
- What is the assessment of Polish production firms of functions of production planning and control?
- What are the clusters in factors affecting production planning and control?

- What are the clusters in functions of production planning and control?

2. Definitions of production control

By the 1950s, production control's scope was expanded somewhat to include materials, machines, and men, still with time focus. There are many definition of production control like that (O'Donnell, 1967; Ploss and Wight, 1967; McKay and Wiers, 2004; Reinfeld, 1952; Arora, 2004; Galvin, 2009; Knod and Schonberger, 2000; Oraipoulos and Kavadias, 2021):

- production control its necessary for the production department to have the raw materials delivered at the proper time, to have the machines available to produce the material at the proper time, and to have the men available to work on the machines,
- production control determines what items and quantities should be made and when they should be made, taking into the account the three basic objectives,
- production control is the orchestration of materials, machines, and personnel through the sequencing, scheduling, initiation and tracking of production orders in order that the required quantities, quality, and customer service are efficiently achieved in a reliable fashion with minimal costs,
- production control is the task of predicting, planning and scheduling work, taking into account manpower, materials availability and other capacity restrictions, and cost so as to achieve proper quality and quantity at the time it is needed and then following up the schedule to see that the plan is carried out, using whatever systems have proven satisfactory for the purpose,
- production control is the activity of monitoring and controlling any particular production or operation, production control is often run for specific control room operations room, with inventory control and quality control, production control is one of the key functions of operation management,
- production control is a process of systematic planning, coordinating and directing of all manufacturing activities and influences to ensure having goods made on time, of adequate quality and reasonable cost,
- production control is an activity involved in handling materials, parts, assemblies and subassemblies from their raw or initial stage to the finished product stage in an organized and efficient manner, it may also include activities such as planning, scheduling, routing, dispatching, storage, etc.,
- production control are the methods and procedures used in the manufacture of products such as planning, dispatching, storage,
- production control is maintaining a balance in activities towards a goal or set of goals evolved during production planning,
- production control is "he process of planning production in advance of operations; establishing the exact route of each individual item, part of assembly; setting

and finishing dates for each important item, assembly and the finished products, and releasing the necessary orders as well as initiating the required follow-up to effective the smooth functioning of the enterprises.

3. Seven tasks of production control

We can distinguish seven main tasks of production control (Figure 1) (Arora, 2004):

- Situation assessment - what is where.
- Crisis identification - what needs immediate attention.
- Immediate resequencing and task reallocation - reactive decisions.
- Complete scenario update - remapping the future.
- Future problem identification - what problems can be foreseen.
- Constraint relaxation and future problem resolution - discounting future problems.
- Scheduling by rote - dealing with the rest of the problem.

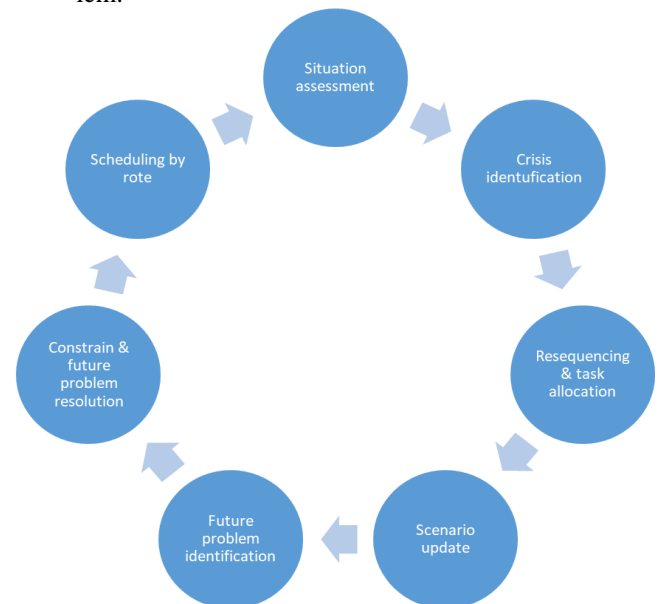


Fig. 1. Scope of operation management (Arora, 2004)

Production planning and control can be defined as the process of planning the production in advance, setting the exact route of each item, fixing the starting and finishing dates for each item, to give production orders to shops and to follow-up the progress of products according to orders (Olkiewicz et al., 2018; Pacana et al., 2014; Pacana and Ulewicz, 2020). Production planning and control is needed to achieve (Kumar and Suresh, 2009; Peinado et al., 2018):

- Effective utilization of firms' resources.
- To achieve the production objectives with respect to quality, quantity, cost and timeliness of delivery.
- To obtain the uninterrupted production flow in order to meet customers varied demand with respect to quality and committed delivery schedule.
- To help the company to supply good quality products to the customer on the continuous basis at competitive rates.

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The main objectives of production planning and control are (Biswas and Chakraborty, 2016; Stevenson, 2002):

- Systematic planning of production activities to achieve the highest efficiency in production of goods/services.
- To organize the production facilities like machines, men, etc., to achieve stated production objectives with respect to quantity and quality time and cost.
- Optimum scheduling of resources.
- Coordinate with other departments relating to production to achieve regular balanced and uninterrupted production flow.
- To conform to delivery commitments.
- Materials planning and control.
- To be able to make adjustments due to changes in demand and rush orders.

4. Factors affecting production planning and control

Production planning and control can be viewed as nervous system of production operation. Production planning and control provides different kinds of information to different departments (Stecula, 2018; Szczucka-Lasota and Wolniak, 2018; Wolniak and Skotnicka-Zasadzień, 2014). It provides information about available manufacturing resources to marketing department. In the next tables we collected main information's about particular characteristics of production planning and control especially: in Table 1 factors affecting production planning and control and in Table 2 functions of production planning and control.

Table 1. Factors affecting production planning and control (Sharma and Sharma, 2014)

Factor	Characteristic
Use of computers	Modern factories are using office automation equipment like PC, punch cards etc. It helps accurate computation of required of men and machine.
Seasonal variations	Demand of certain products is affected by seasons, for instance umbrellas and raincoats during the monsoons and outputs. Production planning and control must take such changes into consideration while planning and control activities of inputs and outputs.

Test marketing	In an aggressive marketing strategy new products are to be test marketed in order to know the trends. This is a short- cycle operation, intermittent in nature and often upsets regular production.
After sales service	This has become an important parameter for success. In after sales services, many items are returned for repair. These are unscheduled work and also overload the production line.
Losses due to unpredictable factors	Losses occur due to accidents, fire and theft of production inputs, mainly materials and components. These are unpredictable. Shortage of input due to such factors upset the planned production schedule in time and quantity.
Losses due to predictable factors	There are losses of inputs, due to natural engineering phenomena like production losses and changes in consumption of materials and occurrence of defectives.
Production of order	There are occasions when last minute prioritization of existing orders due to external pressure takes place. These changes in priority are often decided by sufficiently high level of management.
Design changes	Design changes are issued by R & D and the engineering department. This will necessarily force production planning control change the input materials and process.
Rejection and replacement	There are occasions when sub-assemblies or finished goods are rejected during stage or final inspection. Production planning and control must cater for contingent plans to take care of rework without affecting scheduled quality.

Table 2. Functions of production planning and control (Sharma and Sharma, 2014)

Factor	Characteristic
Estimating	Estimating involves deciding the quantity of products to be produced and cost involved in it on the basis of sales forecast. Estimating manpower, machine capacity and materials required to meet the planned production targets are the key activities before budgeting for resources.
Routing	Routing means, determination of path or route on which manufacturing operations will travel, establishing the sequence of operations to be followed in manufacturing a particular product. This route path is determined in advance. Routing information is provided by product or process engineering function and it is useful to prepare machine loading charts and schedules.
Scheduling	Scheduling involves fixing priorities for each job and determines the starting time and finishing time for each operation, the starting dates and finishing dates for each part, sub assembly and final assembly. Scheduling lays down a time table for production, indicating the total time required for the manufacture of a product and also the time required for carrying out the operation for each part on each machine or equipment.
Loading	Facility loading means loading of facility or work center and deciding which jobs to be assigned to which work center or machine. Loading is the process of converting operation schedules into practice. Loading ensures maximum possible utilization of productive facilities and avoids bottleneck in production.

Dispatching	The functions of routing and scheduling as discussed above are paper work only. No actual production has yet been started. Dispatching is the part of production control that translates the paper work into actual production in accordance with the details worked out under routing and scheduling functions. Dispatching deals with setting the production activities in motion through the release of orders and instructions in accordance with the previously planned timings as embodied in production schedules.
Expediting / follow-up / processing	Expediting or progressing ensures that, the work is carried out as per the plan and delivery schedules are met. Expediting includes activities such as status reporting, attending to bottlenecks or holdups in production removing the same, controlling variations or deviations from planned performance levels, following up and monitoring progress of work through all stages of production, coordinating with purchase, stores, tool room and maintenance departments and modifying the production plans and re-plan if necessary
Inspection	Inspection is the process of examining an object for identification or checking it for verification of quality and quantity in any of its characteristics. It is an important tool for ascertain and controlling the quality of a product. Inspection is an appraisal activity that compares goods or services to a standard.

The main objective of the production control is increasing of the performance of production control department. We can distinguish following functions of the mentioned production control department (Production control, 2018; Gupta and Boyd, 2008):

- provision of raw material, equipment, machines and labor,
- to organize production schedule in conformity with the demand forecast,
- the resources are used in the best possible manner in such a way that the cost of production is minimized and delivery date is maintained,
- determination of economic production runs with a view to reduce setup costs,
- proper co-ordination of the operations of various sections/departments responsible for production,
- to ensure regular and timely supply of raw material at the desired place and of prescribed quality and quantity to avoid delays in production,
- to perform inspection of semi-finished and finished goods and use quality control techniques to ascertain that the produced items are of required specification,
- it is also responsible for product design and development.

Production control department should do many function like:

- Buying material, dealing with suppliers.
- Conducting inventory counts.
- Searching for and finding lost inventory.
- Verifying and correcting inventory and production counts.

- Verifying and correcting engineering and material data.
- Communicating and coordinating activities with support departments.
- Researching and explaining curious numbers in the ERP system.
- Tracking engineering changes and controlling the change.
- Balancing out material and inventory as production changes.
- Receiving and shipping goods, issuing paperwork, contacting carriers.
- Monitoring subcontractors and outsourcing.
- Taking orders, contacting customers, verifying orders.
- Planning work at the day, week, month, year, multi-year levels.
- Crafting work sequences
- Releasing work.
- Dispatching work.
- Planning special periods such as preventative maintenance, line upgrades, vacations.

Many factors influence control of production and operation processes. The nature of production control varies from organization to organization. We can distinguish three main factor influencing control of operation (the description of factors is in the Table 3):

- nature of production,
- nature of operations / activities,
- magnitude of operations.

Table 3. Factors determining operations control ((Production control, 2019)

Factor	Characteristic
Nature of production	In job-oriented manufacturing, products and operations are designed for some particular order which may or may not be repeated in future. Hence production usually requires more time, whereas in a continuous manufacturing system inventory problems are more complex but control operations are rather simple due to fixed process. In mixed stock and custom manufacturing systems the problem of control is further complicated due to simultaneous scheduling of combined process.
Nature of operations/activities	In intermittent manufacturing system the operations are markedly varied in terms of their nature, sequence and duration. Due to this the control procedure requires continuous modifications and adjustments to suit the requirements of each order.
Magnitude of operations	Centralized control secures the most effective coordination but as an organization grows in size, decentralization of some production control functions becomes necessary. The degree to which the performance of an activity should be decentralized depends upon the scope of operations and convenience of their locations.

5. The factors affecting production planning and control in polish production enterprises

On the basis of analysis given in the chapter four we conducted an questionnaire analysis in polish production enterprises about factors and functions affecting planning and control. We have achieved questionnaires' from 30 enterprises from Silesia region in Poland.

On the basis of conducted research we tried to identify what factors and functions are main important in researched enterprises. The assessment was done in 1-5 point scale.

First we analyzed the night factors affecting production planning and control: use of computers; seasonal variations, test marketing, after sales service, losses due to unpredictable factors; loses due to predictable factors; production of order; rejection and replacement. The results of our research are put in Table 3 and Figure 2.

The research has shown that for the interviewed industrial companies the most important factors affecting planning and control are as follows:

- use of computers – rating 4.7;
- design changes – rating 4.0;
- test marketing – rating – 4.0.

Table 4. The assessment of factors affecting production planning and control

Variables	Assessment	Standard deviation
Use of computers	4.73	0.45
Seasonal variations	3.13	0.35
Test marketing	4.00	0.74
After sales service	3.77	0.43
Losses due to unpreclicable factors	3.37	0.49
Losses due to predictable factors	3.77	0.43
Production of order	3.27	0.45
Design changes	4.00	0.53
Use of computers	4.73	0.45

On the basis of our research we can say that nowadays in Industry 4.0 condition the use of computers is most important factor in operation management to achieve proper planning and control over production. The digitalization of all processes is indispensable for all production organizations functioning in industry 4.0 conditions. Also very important are problems connecting with development of new industrial solution – especially R&D of new models and proper marketing of those new solutions of the market. Those problems are main factors to achieve success in the today market and operation managers in production organization should concentrate their efforts on them.

Figure 3 shows the analysis of the 9 factors studied using the agglomeration method. The agglomeration method - Ward's cluster analysis - was used to group the variables.

Two main clusters can be distinguished among the factors studied:

- Cluster 1 contains 6 variables: use of computers, design changes, test marketing, losses due to predictable factors, after sales service, rejection and replacement – the cluster contains day-to-day operational management - it is called **day-to-day production planning and control**.
- Cluster 2 contains 3 variables - seasonal variation; loses to unpredictable factors and production of orders. The variables comprising the cluster are related to the occurrence of abnormal seasonal or random situations that affect operational management in a production organisation. The cluster is called - **unpredictable situations in production planning and control**.

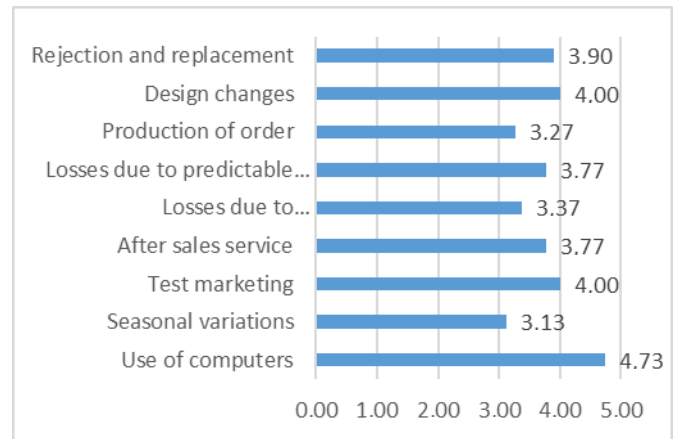


Fig. 2. The results of importance assessment in the case of factors affecting production planning and control

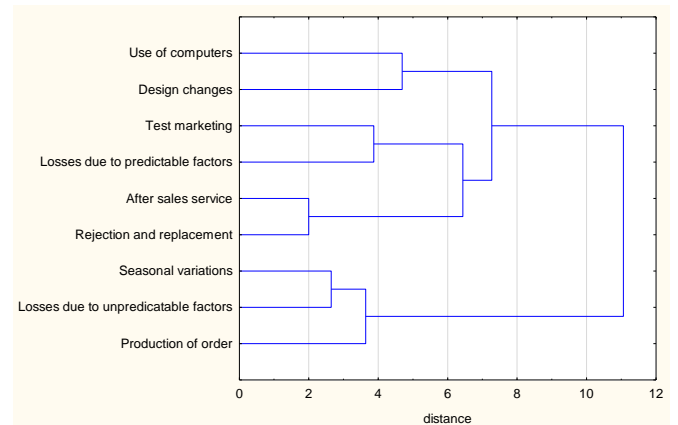


Fig. 3. Cluster analysis for factors affecting production planning and control

Seven functions of production planning and control were also included in the study: estimating, routing, scheduling, loading, dispatching, expediting / processing, inspection. Results of the assessment of importance of those factors which was done by researched organizations are put in Table 5 and Figure 4.

Table 5. The assessment of factors affecting production planning and control

Variables	Assessment	Standard deviation
Rejection and replacement	3.90	0.61
Estimating	4.23	0.63
Routing	3.73	0.78
Scheduling	4.20	0.76
Loading	3.63	0.67
Dispatching	3.63	0.49
Expediting / processing	3.70	0.47

The research carried out showed that for the surveyed industrial companies the most important functions of planning and control are as follows:

- estimating – rating 4.23;
- scheduling – rating 4.23.

In this case we can observe that the main important function of production planning and control are function connected with careful planning, scheduling and estimating of production and logistic parameters: quality of products, costs, sales forecast, job planning etc. In digitalized Industry 4.0 enterprise we can aid those activities using computers and artificial intelligence.

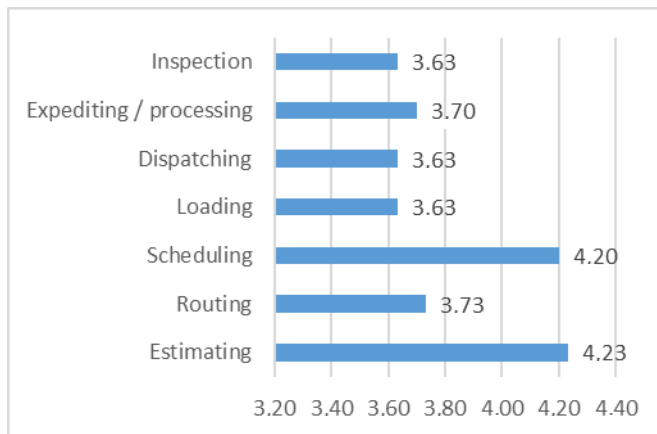


Fig. 4. The results of importance assessment in the case of functions of production planning and control

Figure 5 shows the analysis of the 7 functions of production planning and control with the agglomeration method. The agglomeration method - Ward's cluster analysis - was used to group the variables in this case as well.

Three main clusters can be distinguished among the factors studied:

- Cluster 1 contains 2 variables: estimating and dispatching. The focus was named - **planning and estimating of production**.
- Focus 2 contains 2 variables - scheduling and expediting / processing. The focus is called - **execution of production processes**.
- Focus 3 contains 3 variables - routing, loading and inspection. The focus is called - **logistics and control of production processes**.

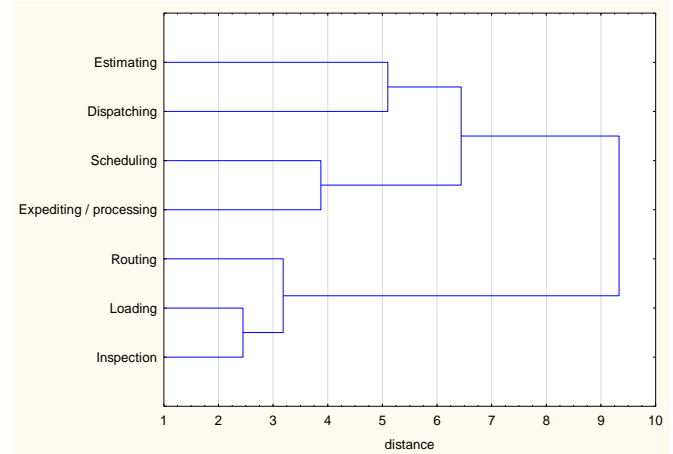


Fig. 5. Cluster analysis for functions of production planning and control

6. Conclusion

In the paper we analysed the problems connected with production control. Nowadays in the conditions of Industry 4.0 this is very important concept because the increasing level of digitalization of all industrial processes leads to possibility of detailed analysis of all processes and better level of control. Operation managers should have good level of knowledge about production control and especially quality control. They can use in this many new information tools like statistical methods and artificial intelligence. Especially we think that in the future many function of production control would be assisted by artificial intelligence.

In the paper we analysed all classical seven task of production management control. Also there is in the paper an research of main factors affecting production control in industrial organization and functions of production planning and control.

In the paper we analyse the research conducted on example of polish production organizations from Silesia region. On the basis of our research the main factors affecting production planning and control are connected with use of digitalized, computer tools in production processes and problems connecting with development of new, innovative solutions. We identified two main clusters of factors affecting production planning and control: day-to-day production planning and control and unpredictable situations in production planning and control.

In the case of function of production planning and control researched organization said that the main important are: estimating and scheduling of production processes. The conducted cluster analysis enable the identification of three clusters of functions of production planning and control: planning and estimating of production; execution of production processes and logistic and control of production processes.

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经营与生产控制的概念

關鍵詞

运行管理
工业企业
产业管理
产品控制
运营经理
工业 4.0
质量管理

摘要

本文的理论目的是分析生产管理在运营管理中的主要功能和概念。本文的实证目的是调查波兰生产企业对影响生产计划和控制的因素以及生产计划和控制的功能的看法。生产控制在每个工厂，运营和生产管理的各个方面都非常重要，尤其是在工业 4.0 时期。在本文中，我们介绍了所有经典的七个生产管理控制任务。本文还分析了影响工业组织生产控制的主要因素。在本文中，我们分析了与生产控制有关的问题。如今，在工业 4.0 的条件下，这是一个非常重要的概念，因为所有工业过程的数字化水平不断提高，导致对所有过程进行详细分析并实现更好的控制水平的可能性。运营经理应该对生产控制，尤其是质量控制有良好的了解。他们可以在许多新的信息工具中使用统计方法和人工智能等工具。尤其是我们认为，人工智能将在未来辅助许多生产控制功能。我们还在本文中给出了对位于西里西亚地区的 30 个波兰生产组织的示例研究的结果。