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The Role of Optimized Operational Planning in Optimal Production Control Toward Defective Production Reduction

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Abstract:

Any optimized operational planning aims to bring about certain goals, including enhancing optimal production control, but it is frustrating to spend time creating an operational plan for any organization and then it fails. To make the organization's efforts of optimized operational planning succeed, ways to master the operational planning reliably must be defined. Therefore, the current study tried to investigate the role of the set of ways to master the optimized operational planning toward enhancing optimal production control to achieve effective reduction of defective production, taking cement plants as a case study. Therefore, the quantitative method for data collection was chosen by using a questionnaire survey for sample of 274 respondents. Findings of the study revealed that the ways to master the optimized operational planning, especially the ways of integrated planning, reliable data and prescriptive analytics, assist significantly in enhancing optimal production control toward achieving the effective reduction of defective production. Based on findings, the study recommended that for manufacturing organizations' management to succeed in enhancing optimal production control, a keen interest must be given towards mastering optimized operational planning, giving them priority as a very vital cost center to effective reduction of defective products.

Keywords: Optimized operational planning; Optimal production control; Defective Production; Cement factories

الملخص:

يهدف أي تخطيط تشغيلي محسّن إلى تحقيق أهداف معينة، بما في ذلك تعزيز التحكم الأمثل في الإنتاج، ولكن من المحبط قضاء الوقت في إنشاء خطة تشغيلية لأي منظمة ثم تفشل. لإنجاح جهود المنظمة للتخطيط التشغيلي الأمثل، يجب تحديد طرق إتقان التخطيط التشغيلي بشكل موثوق. لذلك، حاولت الدراسة الحالية التحقيق في دور مجموعة الطرق لإتقان التخطيط التشغيلي الأمثل نحو تعزيز التحكم الأمثل في الإنتاج لتحقيق خفض فعال للإنتاج المعيب، مع أخذ مصانع الأسمنت كدراسة حالة. لذلك تم اختيارالطريقة الكمية لجمع البيانات باستخدام استبيان استقصائي لعينة من 274 مستجيباً. كشفت نتائج الدراسة أن طرق إتقان التخطيط التشغيلي الأمثل، وخاصة طرق التخطيط المتكامل والبيانات الموثوقة والتحليلات الوصفية، تساعد بشكل كبير في تعزيز التحكم الأمثل في الإنتاج نحو تحقيق الحد الفعال من الإنتاج المعيب. بناءً على النتائج، أوصت الدراسة بأنه لكي تنجح إدارة مؤسسات التصنيع في تعزيز التحكم الأمثل في الإنتاج، يجب إيلاء اهتمام كبير لإتقان التخطيط التشغيلي الأمثل وإعطائها الأولوية كمركز تكلفة حيوي للغاية للحد الفعال من المنتجات المعيبة.

الكلمات المفتاحية: التخطيط التشغيلي الأمثل؛ التحكم الأمثل في الإنتاج؛ إنتاج معيب؛ مصانع الاسمنت.

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پوختە:

ئەرکی هەر پلان دانانێکی کردارەکی کاریگەر بریتی یە لە بەدیهێنانی چەند ئامانجێکی دیاری کراو. بەڵام دارشتنی پلانێکی کردارەکی بۆ هەر رێکخراوێک ئەرکێکی سەختە بە مەبەستی سەرکەوتنی هەوڵەکانی هەر رێکخراوێک لە دانانی پلانێکی کردارەکی کاریگەر، هێڵی رێگاکانی بەدەستهێنانی کارامەیی لە پلاندانانی کردارەکیدا دەبێت بە ڕوونی بکێشرێت.

ئەم توێژینەوەیە هەوڵێکە بۆ لێکۆڵینەوە لە ڕۆڵی کۆمەڵێک ڕێگا کە بەکاردێت بە مەبەستی بەدەستهێنانی کارامەیی لە پرۆسەی پلاندانی کردارەکی کاریگەردا و لە هەمان کاتدا کارامەییەکان کاریگەرن لە کۆنترۆڵکردنی بەرهەم هێنان و کەم کردنەوەی بەرهەم و شمەکی خەوشدار، لەم توێژینەوەیەدا کارگەی چیمەنتۆ وەک میتودی چەندێتی(کوالیتی) پشتپێبەستراوە. هەروەها لە ڕاپرسیەکدا کە تیایدا 274 بەشداربوو وەڵامی پرسیارەکانیان داوەتەوە، دۆزینەوەکانی توێژینەوەکە ئەوەیان پێشانداوە کە ڕێگاکانی بەدەستهێنانی کارامەیی لە دارشتنی پلانێکی کردارەکی کاریگەر بە تایبەت ڕێگاکانی دارشتنی پلانێکی ئاوێتە، کاریگەری مەزنیان هەیە لە کۆنترۆڵکردنی بەرهەم هێنان و لە هەمان کاتدا کاریگەریەکی ئەرێنییان هەیە لە کەم کردنەوەی بەرهەمی خەوشدار.

بە پاڵپشت بە دۆزینەوەکان ئەم توێژینەوەیە پێشنیازی ئەوە دەکات کە ئەگەر بمانەوێت لایەنی بەڕێوەبەرایەتی ڕێکخراوەکان سەرکەوتوو بێت لە کایەی کۆنترۆلکردنی بەرهەمەکان پێویستە جەخت لەسەر بەدەستهێنانی کارامەیی پێویست بکرێت لە بواری پلان دانانی کردارەکیدا و بکرێت بە پێشینە لە بواری کەم کردنەوەی بەرهەمی خەوشدار.

کلیلە وشەکان: دانانێکی کردارەکی کاریگەر، کۆنترۆڵکردنی بەرهەم هێنان، کەم کردنەوەی بەرهەم و شمەکی خەوشدار، کارگەی چیمەنتۆ وەک.

1. Introduction

Just in Time and the concept of lean production have been given greater attention in the current modern era of competitive global market. This has added to the importance of optimized operational planning in the industrial organizations toward achieving the high-level objectives as represented in optimal production control, requiring that a balance be found between production time and optimal use of limited resources within the organizations (Giret *et al*., 2015). As Kumar & Suresh (2009) pointed out, the optimized operational planning warrants optimum productivity by endorsing appropriate utilization of a significant job order and limited resources at different work stations. Consequently, this can result in achieving maximum outputs from machines and raw material. All operational planning-related information is rearranged to create input-output control to attain the overall efficiency of production and optimal exploitation of raw materials (Friedmann, 2020).

Martinich (2008) holds the view that identifying the ways to master the optimized operational planning is a significant factor that helps to determine the effective, efficient and economical operation in a manufacturing unit within organizations. As a result, major problems in relation to productivity, inventory management and resource utilization will be indicated and addressed. It is also used as a useful instrument for detailing the long-term/strategic goals of an establishment. Within an organization, optimized operational planning covers all the activities of formulating a perfect and consistent plan. Tuomikangas and Kaipia (2014) confirm that this plan must be clearly articulated in all the actions that a firm will take to back up the strategic/log-term organizational goals and support all plans as laid out by the upper management. Kumar & Suresh (2009) referred that optimized operational planning is required for optimal production control in terms of scheduling, dispatch, inspection, supply management, inventory management and equipment management. This, in return, guarantees that the production team will be able to achieve one of the

important production targets, which is represented by defective production reduction, thereby leading to cost saving through optimum utilization of resources, quality management.

On the other hand, Kanya (2018) mentioned that the optimized operational planning is considered as the core of the manufacturing process. It is clear that the main purpose of existing optimized operational planning is to arrange the required resources that have substantial roles in handling time, production costs, and labor in manufacturing operations. According to Kaydos (1998), effective operational plan will help manufacturers to achieve their goals, increase productivity, decrease and reduce waste, produce quality commodities and more significantly, satisfy their customers. In addition, Over Head Watch Team (2017) stated that the optimized operational planning of an organization has a positive contribution to the operational and physical sides in relation to employment, business presence and appearance, routine and daily procedures, etc. Subsequently, many people choose to have an optimized operational plan because it guarantees all the aspects of a business are being exploited to the maximum. Magalhães (2017) is of the opinion that without this plan, organizations will not be able to work efficiently and the business risks are kept in focus. Thus, given the importance of the above, this study attempts to discover the actual role that can be played by the set of ways to master the optimized operational planning in enhancing optimal production control to achieve effective reduction of defective production in business organizations. For the purpose of the study, this includes the plants working in the field of cement industry in the Kurdistan region/Iraq. The following part (literature review) of this paper moves on to investigate these types of ways in greater detail.

2. Literature Review and Hypothesis Development

It is obvious that the nature of business planning has dramatically altered, but these changes have not been visible for everyone. In the current age, the ability of systems for analyzing and optimizing establishments to reach peak efficiency is extraordinary and has been creating opportunities for forward-thinking organizations to plan and boost more successfully (River Logic, 2019). Gates (2010) indicates that planning is a technique of attempting to safeguard the resources that are available now and that these resources are used in appropriate manner in order to achieve all desired objectives. Weber (2019) pointed out that the operational plans are the highly detailed plans that provide the clear pictures of how to successfully achieve the organization's goals by the relevant persons and departments. A number of factors play a role in determining the effects of the operational plans. These factors include when an entire department buys-in, assigning due dates for jobs, gauging goals for achievement, reporting on disputes/problems and cooperating effectively.

Thus, operational planning refers to what occurs when teams and units, which are made from an organization-wide strategic plan, are placed under a microscope (Carbone & Gomez-Bravo, 2015). Hill (2019) considers operational planning as the process used to determine all the activities that are required of organizations, units and individual duties to execute the short-term business plan. Likewise, Waldron *et al*. (1997) is of the opinion that the operational plan is in pervasive term that is widely used with business settings and it is curbed to signify those activities required to guarantee the organization meets its present targets and budgets.

However, Shuey *et al*. (2016) mentioned that the optimal operational planning is a technique of properly organizing actions through a process that includes key stakeholders, with the outcomes of the process shared with all relevant individuals. Furthermore, Kumar & Suresh (2009) said that what distinguishes the successful effort in optimal operational planning in industrial organizations

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is that it represents the concrete plans and actions necessary to accomplish the business plans of production processes in a manner that guarantees the optimum productivity. This is by ensuring optimum use of limited resources, which in turn ensure the highest productivity is achieved from machines and raw material in the various production stations. Optimal operational planning also embraces the capital and investment needed to sustain, upgrade and add to production and sales abilities in terms of the organization's strategic plan (Kono & Barnes, 2010). Thus, following the above discussion, seven key ways are addressed in the current study, which will aid to make operational planning and its optimization an unmitigated success towards gaining productive results to improve the competitiveness and financial situation for the business organizations in Iraq, especially those operating in the field of cement industry in Kurdistan -Iraq. These ways to master the optimized operational planning included: reliable data, integrated planning, and understanding context, evaluating value, consistent definitions, testable goals and prescriptive analytics.

In relation to the reliable data, all meaningful operational planning depends on a rock-solid basis of data. Without having a platform in operation to accumulate data on every feature of the organization that produces or consumes value, a knowledgeable effort to improve cannot be made (River Logic, 2019). According to Woo *et al.* (2018), for the organization to be successful in optimized operational planning for their production processes, a data collection platform must be created and the tools acquired to both collect that data and present it in a usable form toward enhancing optimal production control. In addition, reliable data is required in order to design the optimized operational planning which strengthens the overall operational intelligence for the production processes, helping early on to highlight the risks and gaps that occur in the production processes and thus enhancing the ability to optimize production control, which in turn, leads to achieving the effective reduction of defective production through the effective use of available resources (Waldron *et al*., 1997; Ouimet, 2006 and Vercellis, 2009). On the basis of above discussion, the hypothesis below has been formulated.

H1: Reliable data would have a role in enhancing optimal production control to achieve effective reduction of defective production.

River Logic (2019) highlights that integrated and effective operational planning demands an all-inclusive approach which reflects planning and optimization at all levels of production process. Within industrial organizations, what changes at the operational level has an impact on or is cascaded down to tactics and strategies across the organization. He further stresses that the failure to account for these ripple effects eventually cripples most optimization and production control efforts which lead to least improvements in production processes or even losses or waste of available resources. Similar opinions have been articulated by Stevenson *et al*. (2005), who also highlight the importance of the role of correct integrated operational planning in achieving optimal production control, and thus achieving the balance between production time and use of limited resources in a way that leads to achieving the effective reduction of defective production.

By approaching optimization and integrated planning with long-term strategies, budgets, marketing strategies, and with consideration all other features of the organization, the organization can achieve sustained gains in their overall production system. This is in terms of improved production of quality products in a timely manner, at the same time facilitating meeting customer

service requirements, adding to boost the profitability by diminishing costs and making the best use of available resources (Waldron *et al*., 1997; Arn., 2012; Kalsaas *et al*., 2014). However, River Logic (2015) notes that without unified and cohesive planning, every effort can generate ripples of contradiction which causes all efforts apart. This is why older approaches of optimization, those reliant on extrapolating from one angle have generally underachieved. Therefore, it is better to take benefit of modern tools, and work with a whole and clear picture in mind when planning for the production processes in industrial organizations (River Logic, 2019). Thus, the above discussion helps to formulate the following hypothesis.

H2: Integrated planning would have a role in enhancing optimal production control to achieve effective reduction of defective production.

The third way which is important in the successful process of mastering the optimized operational planning in the industrial organizations is understanding context. Understanding context is the way through which the production environment in which an organization operates can be fully understood and analysed, and is thus an important aspect of mastering the operational planning appropriately (Gluck *et al*., 1980; Roley, 2006; River Logic, 2015). River Logic (2019) confirms that it is not enough to look at a change in operational planning and see how it will affect the context of production in the organization alone; it is important to understand how changes in the context of production would enable the organization to control the production in a manner that leads to leading to achieving many of the desired results. Ruch (1994) is of the opinion that highest utilization of production ability is reached by proper development of the machine items which lessens the idle time, as well as maximum utilization of resources in the production process, which in turn, provides a great opportunity to exploit the maximum potential to reduce defective production and facilitating meeting customer requirements, thus positioning the organization within the industry against its nearest competitors (Veltri *et al*., 2013). Otherwise, River Logic (2015) indicates that the failure to account for a wider context in operational planning optimization efforts for production organizations will result in short-sighted plans they will be required to amend and 'optimizations' which bring no outcome. Thus, on the basis of the above discussion the following hypothesis will be made.

H3: Understanding context would have a role in enhancing optimal production control to achieve effective reduction of defective production.

Similarly, evaluating value is considered one of the ways to master the optimized operational planning. River Logic (2019) pointed out that to move forward with an optimization effort of the operational planning for the productive performance, the organization needs a thorough understanding of what value different aspects of its production processes hold. Vlckova & Podskubkova (2018) and Jun & Cai (2001) mentioned that it is easy to look at profit and expenditures and understand the superficial value of an organization. However, access to improved customer interactions resulting from goodwill in providing quality products is flawless, or the benefits of maintaining legacy solutions for a dwindling consumer base is one of the values that the organization needs to make optimal efforts in planning how to reach it. Thus, River Logic (2019) referred that this requires necessary data, the ability to understand how to use it, and access value

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accurately across organization operations. Only then can the organization really understand how a given effort will improve or weaken the overall organization performance. Thus, given the importance of the above discussion, the following hypothesis has been formulated.
H4: Evaluating value would have a role in enhancing optimal production control to achieve effective reduction of defective production.

Consistent definitions are one of the essential ingredients to master the optimized operational planning for production processes in industrial organizations. According to River Logic (2019), the process of nailing down production planning terminology and a general understanding of the various systems, plans, tools, metrics, and other ideas associated with this operation is crucial to making the operational planning and optimization effort successful in terms of the optimum utilization of production capacity, keeping the production level at optimum level, ensuring production cost savings, thereby improving the bottom line by way of controlling wastage of production (Mukhopadhyay, 2015). However, River Logic (2015) pointed out that the discrepancies in how other teams understand terms of operational planning, how they are introduced and defined within their tasks, how to talk about them at all levels from top to down have greater impact. This is because, when taken together, all these can add up to inadequacy and inaccuracies moving forward in terms of the level of the proper completion of operational plans and ensuring a smooth flow of all production processes in a manufacturing environment of an organization (Umble, Haft & Umble, 2003). Based on the above discussion the following hypothesis is been constructed

H5: Consistent definitions would have a role in enhancing optimal production control to achieve effective reduction of defective production.

Another way to help the business organization to master the optimized operational planning is testable goals. River Logic (2019) said that any operational planning and optimization effort is aimed to bring about certain goals, but ambiguous goals are ultimately inadequate for the endeavour. Specific and testable goals are those goals that help the organization make decisions and direct their priorities to be beneficial and achievable (Reilly, 1998). To succeed in efforts to improve the productive performance of any organization, the organization needs to define its goals in a testable way, such as specific numbers it wants to hit, based on its data and value evaluations (Behn, 2003; Siddiqui, 2014). According to Mantec (2019) and Liu & Shyu (1997), the testable goals are those that are achievable and testable based on the existing skills, resources, and knowledge that the organization possesses, which in turn, helps greatly in mastering the optimized operational planning for production lines that would lead to the great benefits such as optimal production efficiency and limit of waste. Thus, the above discussion leads us to announce the following hypothesis.

H6: Testable goals would have a role in enhancing optimal production control to achieve effective reduction of defective production.

The Scientific Journal of Cihan University – Sulaimaniya **PP: 162-180**
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The last way that is also important in mastering the optimized operational planning is prescriptive analytics. River Logic (2019) mentioned that when the organization builds its operational planning and optimization on groundwork of prescriptive analytics, it is constructed on a reliable, consistent platform for improving its production performance. Furthermore, Moe (1984) says that by making data drive the organization decisions and determine how it proceeds to boost operational efficiency, it avoids the traditional drawbacks inherent to any optimization effort. Thus, it will not cling to waste, will not hesitate to invest in useful tools and improvements, and will not make ill-advised 'gut decisions' with no true basis in the data (River Logic, 2015). However, Reilly (1998) referred that in order for this way to be effective in perfecting optimal operational planning for the production processes in any organization, the organization will still need to put time and effort to the greatest efficiency and require reliable tools and a will to trust it; without that, this way is useless to the organization to solve planning problems. Consequently, according to the above discussion, the following hypothesis is being constructed.

H7: Prescriptive analytics would have a role in enhancing optimal production control to achieve effective reduction of defective production.

3. Methodology of Study

The nature of this paper is descriptive and aimed to discover the role of a set of critical ways to master the optimized operational planning in cement industry field. This is because, to date, this matter has received scant attention in the research literature. In light of the above mentioned, the study model is as follows:

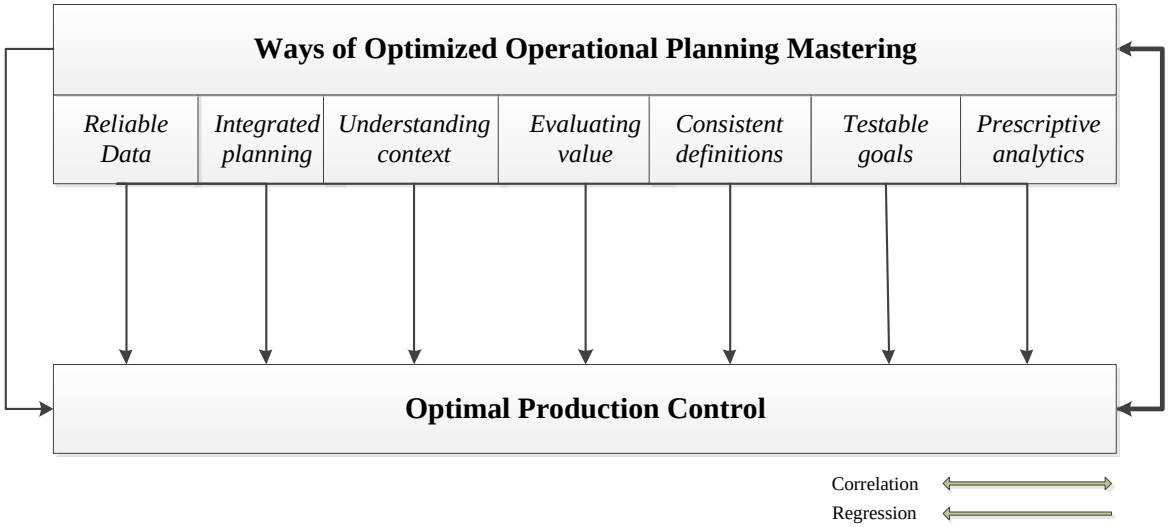

Figure1. Study Model

Source: Organized by the researcher, adapted from River Logic (2019)

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On the basis of sampling table proposed by Krejcie and Morgan (1970), the sample size is 274 respondents (total population 932) in two cement firms under study in the Kurdistan region/Iraq. The researcher was advised by HR department to not mention the factories' name in his study, and thus these names were kept confidential. The sample for each factory was 152 and 122, respectively, based on strata and proportional representation condition of stratified sampling.

Research design is a set of procedures and methods that aid researchers to tie variables in a logical and coherent way. It creates a plan that helps researchers to gather, measure, and analyze data, and find a solution to research problems (Sekaran & Bougie, 2016). As indicated above, the existing study aims to explore and comprehend the role of the set of the critical ways to master the optimized operational planning toward enhancing optimal production control to achieve effective reduction of defective production in two cement plants in the Kurdistan region/Iraq. Therefore, this study uses a quantitative case study approach to investigate the phenomena in which the survey questionnaire was selected to collect data. To ensure reaching robust data and reliable results, the researcher tested the questionnaire via a pilot study that plays a greater role to check the validity and reliability of the survey. In order to be completed by participants, the questionnaire was designed as self-administered. The questionnaire is comprised of three sections. Section one comprised items measuring ways to master optimized operational planning. There were thirty-five items measuring seven ways to master optimized operational planning, which are: reliable data, integrated planning, and understanding context, evaluating value, consistent definitions, testable goals and prescriptive analytics. Participants were asked to respond using a 5-point Likert scale using the level of agreement or disagreement. The second section of the questionnaire elicited information on measuring the optimal production control toward achieving the effective reduction of defective production in terms of the systematic planning, coordinating and systematic and scheduled directing of all industrial activities and impacts to ensure products are made on time and in immaculate condition. Also included were other objects that can reflect the opinions of the workers regarding the optimal production control in their factories. Ten items were used to measure these dimensions, which were also categorized on a 5-point Likert scale on the basis of measuring the proportions of agreement or disagreement. The third section of the survey was devoted to personal information (gender, age, educational level and fieldwork experience). In the survey, a special checklist was used to confirm whether the questionnaire embraces all relevant parts like educational, environmental, organizational, technical aspects. This is regarded as gaining a significant stage as it ensures the questionnaire reaches the aims of the study and to meeting the study objectives.

Having an effective questionnaire design requires the questions to be short, relevant and easy to comprehend, in addition to making sure that the participants understand and interpret the questionnaire questions properly (Brace, 2018). The questionnaire contains open-ended questions to confirm that the questions are interpreted in an objective manner. This certainly improves the reliability and validity of the instrument. The questions were extracted from reliable theories and relevant literature. In addition, to increase the reliability of measures and to build validity, the questionnaire was previously tested by academics and practitioners in the field of the optimized operational planning and optimal production control. This is to confirm that all terms used were related to the subjects. At the same time, the procedures of data collection have been written in detail to ensure that the process is able to be replicated and that good reliability is enabled.

The questionnaire survey went through several procedures. From outset, the first draft of the questionnaire was formulated, and then it went to pre-testing. The questionnaire was formally launched via email and from time to time a gentle reminder was sent to the receivers. Based on the study, objective questions were articulated to cover all related aspects. The content of the question and formula had been sensibly selected by the academic arbitrators with educational level and scientific title (Dr., Professor and Assistant Professor) and other colleagues and Ph.D. Remarks were also revised and implied in the final version of the questionnaire. While the questionnaire translated into the Kurdish language (which is the dominant language in the field of research in the current study) was carefully scanned to ensure its authenticity and authenticity. As well as, the notes of the academic arbitrators were also revised and implicitly included in the Kurdish version of the questionnaire.

The Kurdish version of the questionnaire was then inspected practically by matching it to the actual field work. This was done via sending the questionnaire and a cover letter to the participants in one of the cement factories to ensure its reliability. Production Manager was asked to write his opinion and reflection on how flawless the questions were and how easy they were to answer. Next, the questionnaire was reviewed and retested again with the same manager. When the researcher was satisfied with the questionnaire, the required number of survey questionnaires had been copied and were given to the participants through managers at the top level in the factories. The data was then gathered and received from each of the respective factories. It should be noted that the process of the data collection was made possible due to the efficient and appropriate assistance from administrative staff. Without their help, the process would be difficult and inappropriate. The total number of participants was 274, which represent the sample of the study. As indicated above, the adopted method was proportional sampling method under stratified sampling method. This is what the aim of this study necessitates. Of 274 participants who were sent the questionnaire, 221 returned their responses, of which 15 were ignored due to their incorrectness. Consequently, the final sample for data analysis was 206, reflecting a response rate of 75.18%.

4. Results and Discussion

This below section of this study moves on to discuss in greater detail the results of the survey questionnaire and the statistical methods that were used to test the hypotheses. This was done to gain more knowledge and in-depth information about the impact that can the set of mastering ways of optimized operational planning occur on improving the production control towards achieving an effective reduction in defective production in two cement plant in Kurdistan region / Iraq.

4.1.Profile of Respondents

This section represents the respondents' profiles. Simple frequency counts were employed to allocate the respondents based on their personal characteristics: gender, age, and field work experience and education level. The profile of respondents is shown in Table 1.

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Table 1. Respondents Background (*N* = 206)

Respondents Background							
Gender		**Age**		**Field work experience**		**Education level**	
Items	N (%)	Items	N (%)	Items	N (%)	Items	N (%)
Male	162(78.64)	Under 25 years	59(28.64)	<5 years	47 (22.82)	High School Graduate	31(15.05)
Female	44 (21.36)	25-34 years	76(36.89)	5-10 years	78 (37.86)	Diploma Degree	58(28.16)
		35-45 years	51(24.76)	11-15 years	46 (22.33)	Bachelor Degree	112(54.37)
		Over 45 years	20(9.71)	>15 years	35 (16.99)	Advanced Degree	5(2.42)

As shown in Table 1, the data of gender shows that there were more male (78.64%) than female employees (21.36%). This distribution is a real reflection for the reality of workers in most industrial and service sectors in the Kurdistan Region-Iraq. As for age, 36.89% of the workforce were between 25-34 years old; 28.64% were under 25; 24.76% were between the ages of 35- 45; and only 9.71% were over 45 years of age. From the data, it can be said that the respondents were young and energetic people who would be able to master the ways of operational planning optimally to enhance production control toward achieving the effective reduction of defective production in their plants. Field work experience indicates that the majority of the respondents had been employed with their current organizations for more than 5 years but less than 10 years (37.86%), followed by respondents who were employed for less than 5 years (22.82%), respondents who were working between 11- 15 years (22.33%), and with more than 15 years of experience (16.99%). These results indicate that most of the respondents have had good experience in the field of optimized operational planning and thereby have the aptitude in mastering the ways of operational planning which guarantee the optimal production control to achieve the defective product reduction skills in their plants. The distribution of the employees' educational backgrounds indicated that the majority (54.37%) had received a bachelor's degree; 28.16% held a diploma degree; 15.05% held a high school graduate degree and 2.42% held an advanced degree of the education. The results show that a minority of employees own high educational level toward mastering the ways of optimized operational planning to enhance production control toward achieving the effective reduction of defective production and enhancing the overall production efficiency in their plants.

The Scientific Journal of Cihan University – Sulaimaniya **PP: 162-180**
Volume (4), Issue (2), December 2020
ISSN 2520-7377 (Online), ISSN 2520-5102 (Print)

4.2.Pearson Correlation Analysis for Variables

Pearson Correlation was conducted to establish the relationship between the ways to master operational planning and the optimal production control towards achieving the effective reduction of defective production. Pearson correlation checks for important association between variables (Sekaran & Bougie, 2016). The results of the correlation are shown in Table 2.

Table 2. Correlation Matrix for Variables of Study

	Reliable Data	Integrated Planning	Understanding Context	Evaluating Value	Consistent Definitions	Testable Goals	Prescriptive Analytics	Optimal Production Control
Reliable Data	1							
Integrated Planning	.583**	1						
Understanding Context	.589**	.574**	1					
Evaluating Value	.541**	.574**	.581**	1				
Consistent Definitions	.529**	. 582**	.574**	.501**	1			
Testable Goals	.590**	.597**	.568**	.485**	.551**	1		
Prescriptive Analytics	.517**	.501**	.519**	.467**	.462**	.481**	1	
Optimal Production Control	.574**	.586**	.582**	.489**	.528**	.559**	.583**	1
**. Correlation is significant at the 0.01 level (2-tailed).								

The Pearson correlation coefficient findings in Table 2 illustrate a slightly strong and positive relationship between the ways (dependable data, incorporated planning, considerate context, evaluating value, reliable definitions, testable objectives and prescriptive analytics) of the optimized operational planning and the optimal production control. As soon as the association was proven between variables, a regression analysis which employed both linear and multiple regression techniques were conducted in order to gain a better understanding of the impact of the ways to master optimized operational planning on optimal production control, as well to ensure which way of optimized operational planning is the most persuasive on enhancing optimal production control, thereby achieving the effective reduction of defective production within designated factories under study. The findings of the analysis are offered in the below section.

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The Scientific Journal of Cihan University – Sulaimaniya **PP: 162-180**
Volume (4), Issue (2), December 2020
ISSN 2520-7377 (Online), ISSN 2520-5102 (Print)

4.3.Regression Analysis for Optimized Operational Planning and Optimal Production Control

A linear and multiple regression analysis was performed in order to examine the effect of the ways to master operational planning on optimal production control, as well which way of optimized operational planning is the most persuasive on enhancing optimal production control within the plants under study. It is worth mentioning that before applying regression analysis, assumptions pertaining to regression were satisfied. The reliability of the instrument was found to be 0.829 (ways to master operational planning) and for optimal production control (0.775). Reliability using Cronbach's alpha designated that the gadget was reliable as all the alpha values were found to be above 0.70. The factor analysis showed that the instrument was valid as all the objects were found to have more than 0.40 factor loadings and were retained. Findings of linear and multiple regression analysis are illustrated in Tables 3 and 4, respectively.

Table 3. Linear Regression Analysis for OOP with OPC Model

Model	**R**	**R^2**	**Adj. R^2**	***F***	**Sig.**	**Beta**	**t**	**Sig.**
1	.641	.428	.453	68.287	0.000			
Intercept						0.487	9.091	.000
OMHE						.376	7.092	.000

Predictors: (Constant), Optimized Operational Planning (OOP)
Dependent Variable: Optimal Production Control (OPC)

To test the influence of the composite variable of ways to master operational planning on optimal production control, as shown in Table 3, simple leaner regression was used. The consequences of the current study displayed that ways to master optimized operational planning play a huge role in the success of optimal production control. The findings indicated that the ways to master operational planning as an independent variable have a strong and positive relationship (R = 0.641) with the dependent variable of optimal production control. The results also showed that the value of R Square here is 0.428. This means that the ways to master operational planning cause 42.8% variation in optimal production control. Similarly, the findings indicated that the ways to master operational planning have a significant influence ($\beta = 0.376$, $p < 0.05$) on optimal production control. This result shows that the ways to master operational planning alone will have an influence of 37.6% on optimal production control.

The Scientific Journal of Cihan University – Sulaimaniya **PP: 162-180**
Volume (4), Issue (2), December 2020
ISSN 2520-7377 (Online), ISSN 2520-5102 (Print)

Table 4. Multiple Simultaneous Regression Analysis for Ways of Optimized Operational Planning Mastering with Optimal Production Control Model

Model	**R**	**R^2**	**Adj.R^2**	***F***	**Sig.**	**β**	***t***	***P***
	.627	.386	.439	67,524	.000			
Reliable Data						.572	10.543	.000
Integrated Planning						.596	10.581	.000
Understanding Context						.559	10.338	.000
Evaluating Value						.356	7.427	.031
Consistent Definitions						.561	10.386	.000
Testable Goals						.440	8.601	.019
Prescriptive Analytics						.571	10.468	.000

Predictors: (Constant) Reliable Data, Integrated Planning, Understanding Context, Consistent Definitions, Testable Goals, Prescriptive Analytics
Dependent Variable: Optimal Production Control

The multiple regression findings indicate that integrated planning, prescriptive analytics, reliable data, consistent definitions and understanding context, respectively, are the most influential ways of optimal production control toward achieving the effective reduction of defective production. Similarly, the way of testable goals ranked second in terms of impacting on optimal production control. However, the results displayed that the way of evaluating value has a somewhat minimal impact on optimal production control.

As for the way of reliable data, the regression findings referred that this way has significant influence ($\beta = 0.572$, $p < 0.05$) on enhancing optimal production control towards achieving the effective reduction of defective production positively. The researchers (Woo *et al*., 2018) confirmed that for an organization to be successful in optimized operational planning for their production processes, a reliable platform of data collection must be created and an instrument to collect relevant data and deliver it in a usable form towards enhancing optimal production control acquired. Furthermore, Waldron *et al*. (1997); Ouimet (2006); Vercellis (2009) pointed out that reliable data is required in order to design the optimized operational planning which strengthens the overall operational intelligence for the production processes, helping early on to highlight the risks and gaps that occur in the production processes, thereby enhancing the ability to optimize production control toward achieving the positive reduction of defective production through the optimal use of available resources. Thus, the above discussion leads us to accept the following hypothesis.

H1: *Reliable data would have a role in enhancing optimal production control to achieve effective reduction of defective production.*

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The Scientific Journal of Cihan University – Sulaimaniya **PP: 162-180**
Volume (4), Issue (2), December 2020
ISSN 2520-7377 (Online), ISSN 2520-5102 (Print)

With regard to the way of integrated planning, the regression results indicated that this way had a greater impact ($\beta = 0.596$, $p < 0.05$) compared to other ways on the optimal production control toward the positive achieving defective production reduction. The result suggests that the optimal use of integrated planning way has a positive impact not only on optimal production control, but it also has an influence on every level of the production process and on the tactics and strategies across the organization (River Logic, 2019). They further stress that the failure to account for these ripple effects eventually cripple most optimization and production control efforts, which cause small improvements in production processes or even loss or waste of available resources. In addition, Stevenson *et al*. (2005) confirmed the importance of the role of correct integrated operational planning in achieving optimal production control, thus achieving the balance between production time and use of limited resources in a way that leads to achieving the effective reduction of defective production. So, the regression analysis for the model of ways to master operational planning-optimal production control displays that its results support the second hypothesis; therefore, this hypothesis has been accepted.

H2: *Integrated planning would have a role in enhancing optimal production control to achieve effective reduction of defective production.*

The findings also showed that the way of understanding context has a positive effect ($\beta = 0.559$, $p < 0.05$) on the issue of improving optimal production control. Many researchers such as Gluck *et al*. (1980), Roley (2006) and River Logic (2015) confirmed that understanding context is the way through which the production environment in which an organization operates can be fully understood and analyzed, which is an important aspect of mastering the operational planning appropriately. Moreover, River Logic (2019) confirms that it is essential to understand how the change in operational planning will occur in the context of production in a way that would make the organization be able to control the production and confirm the attainment of optimal exploitation of production ability by proper scheduling of the machine materials, which diminishes the idle time (Ruch, 1994). In addition, understanding context helps to optimize utilization of resources in the production process, thereby providing an excellent opportunity to exploit the maximum potential to reduce defective production and facilitate meeting customer requirements, thus position the organization within the industry against its nearest competitors (Veltri *et al*., 2013). Thus, based on the discussion above, the following hypothesis is accepted.

H3: *Understanding context would have a role in enhancing optimal production control to achieve effective reduction of defective production.*

The findings indicate that evaluating value has somewhat of an influence ($\beta = 0.356$, $p < 0.05$) on the issue of enhancing optimal production control, which is considered of the necessities to lead the factories under study toward achieving the reduction of defective production positively. River Logic (2019) confirm that to improve the operational planning for the productive performance and thereby enhancing overall production efficiency, the organization needs a thorough understanding of what value different aspects of its production processes hold. They also referred that it was necessary to acquire the necessary data, figure out how to interpret it usefully, and access value

accurately across organization operations. Only then can the organization really understand how a particular effort will improve or weaken the operational performance of the organization as a whole. Based on the above discussion, the following hypothesis is accepted.

H4: *Evaluating value would have a role in enhancing optimal production control to achieve effective reduction of defective.*

As for the consistent definitions way, the regression findings referred that this way has also a significant influence ($\beta = 0.561$, $p < 0.05$) on the optimal production control toward enhancing the effective reduction of defective production, which has been confirmed by several researchers such as (Logic, 2019; Mukhopadhyay, 2015). These researchers reported that the process of nailing down production planning terminology and a general understanding of the various systems, plans, tools, metrics, and other ideas associated with this operation is crucial to making the operational planning and optimization effort successful in terms of the optimum utilization of production capacity, keeping the production level at the optimum level, ensuring production cost savings thereby improving the bottom line control wastage of production. Thus, the above discussion makes us accept the following hypothesis.

H5: *Consistent definitions would have a role in enhancing optimal production control to achieve effective reduction of defective production.*

However, the findings showed that the testable goals have a somewhat positive effect ($\beta = 0.440$, $p < 0.05$) on the issue of improving optimal production control. River Logic (2019) reported that any operational planning and optimization effort aim to bring about certain goals, but vague goals are ultimately useless for the endeavor. Specific and testable goals are those goals that help the organization make decisions and direct their priorities to be beneficial and achievable (Reilly, 1998). To succeed in efforts to improve the productive performance of any organization, the organization needs to define its goals in a testable way; specific numbers it wants to hit, based on its data and value evaluations (Behn, 2003; Siddiqui, 2014). Thus, based on the discussion above, the following hypothesis is accepted.

H6: *Testable goals would have a role in enhancing optimal production control to achieve effective reduction of defective production.*

As for the prescriptive analytics, the regression results showed that this way has significant influence ($\beta = 0.571$, $p < 0.05$) on enhancing optimal production control towards achieving the effective reduction of defective production properly. River Logic (2019) reported that when the organization builds its operational planning and optimization on a foundation of prescriptive analytics, it is building on a reliable, consistent platform to improve its production performance. Moe (1984) also confirmed that by making data drive the organization decisions and determine how it proceeds to enhance operational efficiency; the traditional pitfalls inherent to any optimization effort can be avoided. Thus, it will not cling to waste, will not hesitate to invest in useful tools and improvements, and will not make ill-advised 'gut decisions' with no true basis in the data (River Logic, 2015). Based on the above, the following hypothesis was accepted.

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The Scientific Journal of Cihan University – Sulaimaniya **PP: 162-180**
Volume (4), Issue (2), December 2020
ISSN 2520-7377 (Online), ISSN 2520-5102 (Print)

H7: *Prescriptive analytics would have a role in enhancing optimal production control to achieve effective reduction of defective production.*

5. Material Differences Between the Current and Past Studies

The overall aim of this study is to obtain knowledge and in-depth information about the effect of the ways to master operational planning on optimal production control toward achieving the effective reduction of defective production in the selected cement factories in Kurdistan region / Iraq. Through this objective, it should be noted that the current study focuses on examining the active role of the different dimensions which are used in optimized operational planning mastering to enhance overall production efficiency through the issue of improving optimal production control and thereby achieving the effective reduction of defective production. This is opposite to what was conducted in many previous studies such as McLaughlin *et al.* (1991); Gaskill & Van Auken (1994); Kono & Barnes (2010); Olhager (2013); Mateljak & Mihanović (2016); George *et al.* (2019) in the area of operational planning. These studies were concentrated on examining other activities such as inventory, marketing, financial, and personnel, planning raw and materials, work planning, planning tools and equipment, capacity planning, in order to improve the ability of mastering operational planning toward improving organizational performance and profitability in the business organizations. This is without realizing the fact that it is also necessary to examine the extent of the impact of the other ways which were addressed in the current study to master operational planning optimally, thereby enhancing overall production efficiency by enhancing optimal production control and facilitating better customer care by producing better quality products in a timely manner.

6. Conclusion and Practical Implications

Taken together, the findings of this study suggested that there was a significant positive association between ways to master operational planning and optimal production control. The results were in line with previous studies which confirm that enhancing optimal production control by optimized operational planning can be leading dramatically to achieve effective reduction of defective production and thereby enhance overall production efficiency. It is essential to prove here that from the regression analysis, the mastering of operational planning optimally has a great role in improving the skills of production control, which in turn, lead to improve the skills of reducing defective products, thereby enhancing the efficiency of the productive performance of the industrial organizations and assists in maintaining their business, productivity and profitability and thereby their survival in the present global economic environment.

Although the findings of the study offer valuable insights and interesting results, the most important limitation lies in the fact that the size of the samples was small. Accordingly, the generalizability of these results is subject to certain limitations, as only two organizations from the cement industry sector in the Kurdistan region were selected as cases located out of Sulaimani city. Thus, it is believed that having a bigger sample size and including more industrial organizations may produce other data. Furthermore, other limitations will be emerged when it is implemented. These limitations include 1) it is going to be difficult to get permission from authorities to carry out the study due to security issues in Iraq; 2) other limitations include time restriction and the cost of

travel to organizations under study; 3) insufficient academic publications in Iraq particularly and the Middle East generally.

However, the practical implications of the current paper are represented in providing a framework consisting of the set of the necessary ways to master the operational planning optimally, which can then be used by industrial organizations to enhance production control perfectly toward improving many critical issues in the productive system, including the defective product reduction skills in view of continuously improving productive efficiency. Moreover, the factories senior management would benefit by knowing which one of the ways of operational planning mastering should receive the greatest attention to enhance optimal production control, gaining several comparative advantages in terms of designing the optimized operational planning which strengthens the overall operational intelligence for the production processes, achieving the balance between production time and use of limited resources, as well helping early on to highlight the risks and gaps that occur in production processes. These are necessary in order to achieve the real lasting gains in the overall production system for the organization in terms of enhancing the ability to optimize production control and then better production of quality products, while at the same time facilitating meeting customer service requirements, adding to enhance the profitability by minimizing costs and making the best use of available resources, enabling the organization to position itself within the industry against its nearest competitors.

References

Arn, E. A. (2012). *Group technology: an integrated planning and implementation concept for small and medium batch production*. Springer Science & Business Media, New York, USA.

Behn, R. D. (2003). Why measure performance? Different purposes require different measures. *Public administration review*, *63*(5), 586-606.

Brace, I. (2018). Questionnaire design: How to plan, structure and write survey material for effective market research. Kogan Page Publishers.

Carbone, G., & Gomez-Bravo, F. (Eds.). (2015). *Motion and operation planning of robotic systems: background and practical approaches* (Vol. 29). Springer, Switzerland.

Friedmann, J. (2020). Planning in the public domain: From knowledge to action. Princeton University Press.

Gaskill, L. R., & Van Auken, H. E. (1994). Impact of operational planning on small business retail performance. *Journal of Small Business Strategy*, *5*(1), 21.

Gates, L. P. (2010). *Strategic planning with critical success factors and future scenarios: An integrated strategic planning framework* (No. Cmu/Sei-2010-Tr-037). Carnegie-Mellon Univ Pittsburgh Pa Software Engineering Inst.

George, B., Walker, R. M., & Monster, J. (2019). Does Strategic Planning Improve Organizational Performance? A Meta-Analysis. *Public Administration Review*, *79*(6), 810-819.

Giret, A., Trentesaux, D., & Prabhu, V. (2015). Sustainability in manufacturing operations scheduling: A state of the art review. *Journal of Manufacturing Systems*, *37*, 126-140.

Gluck, F. W., Kaufman, S. P., & Walleck, A. S. (1980). Strategic management for competitive advantage. *Harvard business review*, *58*(4), 154-161.

Hill, B. (2019). The Importance of Planning in an Organization. available at https://smallbusiness.chron.com/importance-planning-organization-1137.html (accessed 1 May 2020).

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The Scientific Journal of Cihan University – Sulaimaniya **PP: 162-180**
Volume (4), Issue (2), December 2020
ISSN 2520-7377 (Online), ISSN 2520-5102 (Print)

Jun, M., & Cai, S. (2001). The Key Determinants of Internet Banking Service Quality: A Content Analysis, *International Journal of Bank Marketing*, *19*(7), pp. 276-291.

Kalsaas, B. T., Grindheim, I., & Læknes, N. (2014, June). Integrated planning vs. Last Planner system. In *Kalsaas, BT, Koskela, L. and Saurin, TA, 22nd Annual Conference of the International Group for Lean Construction, Oslo, Norway* (pp. 639-650).

Kanya. (2018). Manufacturing Tips: How to Optimize Your Production Planning. available at https://www.hashmicro.com/blog/production-planning-optimization/ (accessed 30 April 2020).

Kaydos, W. (1998). *Operational performance measurement: increasing total productivity*. CRC press.

Kono, P. M., & Barnes, B. (2010). The role of finance in the strategic-planning and decision-making process. *Graziadio Business School Review*, *12*(1), 19-87.

Kumar, S. A., & Suresh, N. (2009). *Operations management*. New Age International.

Liu, S. J., & Shyu, J. (1997). Strategic planning for technology development with patent analysis. *International Journal of Technology Management*, *13*(5-6), 661-680.

Magalhães, I. L. (2017). How to improve the Operational Efficiency of the organization?. available at https://www.linkedin.com/pulse/how-improve-operational-efficiency-organization-ivan-luizio-magalh%C3%A3es (accessed 30 April 2020).

Mantec. (2019). How to Create A Strategic Plan with Smart Goals. available at https://mantec.org/strateginc-plan-smart/ (accessed 7 May 2020).

Martinich, J. S. (2008). *Production and operations management: An applied modern approach*. John Wiley & Sons, New York, USA.

Mateljak, Ž., & Mihanović, D. (2016). Operational planning level of development in production enterprises in the machine building industry and its impact on the effectiveness of production. *Economic research-Ekonomska istraživanja*, *29*(1), 325-342.

McLaughlin, C. P., Pannesi, R. T., & Kathuria, N. (1991). The different operations strategy planning process for service operations. *International Journal of Operations & Production Management*.

Moe, T. M. (1984). The new economics of organization. *American journal of political science*, 739-777.

Mukhopadhyay, S. K. (2015). *Production planning and control: Text and cases*. PHI Learning Pvt. Ltd..

Olhager, J. (2013). Evolution of operations planning and control: from production to supply chains. *International journal of production research*, *51*(23-24), 6836-6843.

Ouimet, K. J. (2006). *U.S. Patent No. 6,988,076*. Washington, DC: U.S. Patent and Trademark Office.

Over Head Watch Team. (2017). Operational Planning 101: What It is and How to Plan One. available at https://overheadwatch.com/operational-planning/ (accessed 30 April 2020).

Reilly, A. J. (1998). Three approaches to organizational learning. *The Pfeiffer Library*, *16*(2),1-3.

River Logic. (2015). The Keys to Successful Operational Planning and Optimization. available at https://blog.riverlogic.com/the-keys-to-successful-operational-planning-and-optimization (accessed 4 May 2020).

River Logic. (2019). Why Optimization Should Be Top of Mind for Operational Planning. available at https://blog.riverlogic.com/why-optimization-should-be-top-of-mind-for-operational-planning (accessed 30 April 2020).

Roley, P. (2006). Strategic management for competitive advantage. *Harvard Business Review*, *108*(9), 163-123.

Ruch, W. A. (1994). Measuring and managing individual productivity. *Organizational linkages: Understanding the productivity paradox*, 105-130.

Sekaran U and Bougie R. (2016). *Research methods for business: a skill building approach*. Hoboken: John Wiley & Sonsm New York, USA.

Shuey, D., Bigdeli, M., Rajan, D. (2016). Operational planning: transforming plans into action. World Health Organization.

Siddiqui, M. N. (2014). Success of an organization is a result of employees performance. *Advances in Social Sciences Research Journal*, *1*(4), 179-201.

Stevenson*, M., Hendry, L. C., & Kingsman, B. G. (2005). A review of production planning and control: the applicability of key concepts to the make-to-order industry. *International journal of production research*, *43*(5), 869-898.

Tuomikangas, N., & Kaipia, R. (2014). A coordination framework for sales and operations planning (S&OP): Synthesis from the literature. *International Journal of Production Economics*, *154*, 243-262.

Umble, E. J., Haft, R. R., & Umble, M. M. (2003). Enterprise resource planning: Implementation procedures and critical success factors. *European journal of operational research*, *146*(2), 241-257.

Veltri, A., Pagell, M., Johnston, D., Tompa, E., Robson, L., Amick III, B. C., ... & Macdonald, S. (2013). Understanding safety in the context of business operations: An exploratory study using case studies. *Safety science*, *55*, 119-134.

Vercellis, C. (2009). *Business intelligence: data mining and optimization for decision making* (pp. 1-420). New York: Wiley.

Vlckova, V., & Podskubkova, L. (2018, September). Customer service quality in B2B market from the buyer's perspective. In *10th International Scientific Conference „Business and Management 2018 "*.

Waldron, M. W., Vsanthakumar, J., & Arulraj, S. (1997). Improving the organization and management of extension.

Weber, J. L . (2019). Operational Planning: How to Make an Operations Plan. available at https://www.projectmanager.com/blog/operational-planning-make-operation-plan (accessed 1 May 2020).

Woo, J., Shin, S. J., Seo, W., & Meilanitasari, P. (2018). Developing a big data analytics platform for manufacturing systems: architecture, method, and implementation. *The International Journal of Advanced Manufacturing Technology*, *99*(9-12), 2193-2217.

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