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Operations Planning For Decision-Making In The Industry

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Abstract

Aggregate planning is a medium-term production plan feasible from the workforce's capabilities and levels. This article presents a literature review of its influence and impact on the manufacturing industry, where current strategies are analyzed and applied in diverse industrial sectors. After the decision-making leading to model structuring, different solution methods for the aggregate planning models and their main features are identified. Consequently, they are solved by using computer tools easing their application and understanding. Finally, we analyzed the industries that have applied aggregate planning to demonstrate this planning method's flexibility in different manufacturing industries. This paper offers a quality alternative for accessing information about aggregate planning and its implementation in the manufacturing sector.

Keywords: Production plan, production planning strategies, industrial sectors, aggregate planning software

1. Introduction

Aggregate planning can be defined as a production plan that is feasible from a capability approach and allows achieving the plan with strategies in the best possible way with the tactical objectives of the operations subsystem [1].

The aggregate operations plan defines production rates by product families or other categories over the medium term (3 to 18 months). The main objective of the aggregated operations plan is to specify the optimal combination between the production rate, labor force level and inventories [2]. A good aggregate planning results in a reasonable use of available resources in the manufacturing organization

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[3]. They are those activities that must be executed to achieve business goals that will culminate in fulfilling the demand for each period established in the production planning [4]. Manufacturing industries generally involve highly complex manufacturing operations, thus requiring adequate decision support for aggregate planning [5]. Table 1 shows the characteristics to consider in the development of aggregate planning.

Table 1. Characteristics of aggregate planning

Characteristic	Description
Strategies	Leveling
	Chase
	Mixed
Performance measures	Costs
	Utility
Solution methods	Mathematical programming
	Simulation
	Heuristics

As for strategies based on constant production or leveling, where the production rate is considered fixed, which leads to reduced hiring and firing costs, product quality is increased, compliance with production plans is facilitated, and labor and raw material costs are reduced. In this strategy, inventories become essential to adapt the uniform production rhythm to the oscillations of demand, accumulation of orders and loss of sales. The demand tracking or chasing strategy adjusts the production rhythm according to each period's requirements, so the inventory level is practically non-existent. This strategy requires flexibility in labor, installed capacity and raw material; finally, mixed strategies consist of the optimal mix of the previous ones [6]. The aggregate plans can achieve higher profits and avoid suboptimal results [7]. However, they are also used to minimize costs where an objective function of labor and other inventory management costs is proposed in the analyzed period [8].

In the solution of an aggregate planning model, techniques such as fuzzy logic can be used, which takes into account the uncertainty of the imprecision of statistical or non-statistical information [8]. Linear programming allows knowing each of the alternatives that can be applied in the company to meet the production since it is a systematic and innovative technique that takes into account the variables involved in the production and optimizes the resources used by the company to produce a product [9]. Simulation helps estimate the demand and capacity starting from techniques that allow experimenting and formulating different plans so that an adequate activity scheduling plan can be generated [10]. It can be solved using solution packages such as Lingo (or GAMS), among others [11].

At a global level and in economic powers such as Japan, the United States and Germany, there is evidence of high economic growth and employment levels sustained by a strong manufacturing sector. However, the relative loss of weight of the manufacturing industry in a country is accompanied by a deterioration, which is why national governments must pay special attention to the behavior of their manufacturing industry if they do not want to suffer complications from such a decline. It is also argued that from a weight of 20% of the industrial manufacturing sector in a country's economy, the balance of goods and services determines a positive value, which would indicate the convenience of maintaining a manufacturing industry of approximately one-fifth of the gross value added of a country's total economy to be able to have positive balances in the balance of goods and services [12]. At the Latin American level, in Uruguay, there is a growing importance of the manufacturing sector in process innovation. The food, beverages and tobacco industries have the highest investment in innovation and development, followed by textile and wood, with the main improvement activities being the acquisition of capital

goods (29.1%), and training (26.9%), among others [13]. The importance of the manufacturing sector in Mexico can be seen evidenced in the country's exports as one of the most significant foreign exchange generators, with a participation of around 90% by mid-2017, according to the Bank of Mexico [14]. In Colombia, the importance of the manufacturing sector is evidenced by its share in the national GDP, which during the period 2000-2005 averaged 14.5%, surpassing large sectors such as agriculture, commerce and construction [15].

The following research conducted a literature review related to the aggregated operations plan, such as: Dejonckheere, Sidney, Lambrecht, and Towill (2003), analyzed the literature allowing to determine the development of computer tools for applicability in an aggregated planning model, in addition to characterizing the aggregated planning of operations as a dynamic system and comparing solution strategies such as level, pursuit and pragmatic [16]; Boiteux, Corominas, Lusa (2007), conducted a literature review, in which they detected the limitations in proposed models, as well as recommending new research approaches that allow aggregate planning, to become a tool to integrate the activities of the main areas of the company in the medium term, and thus, to ensure its operation and improving efficiency and overall benefits [17]; Camacho and Sanchez (2017), conducted a literature review which was focused on the concept of aggregate planning, modeling and solution techniques most used in various industrial sectors according to different variables of study, coming to find that integer linear programming is the most used model to solve aggregate planning problems in industries such as automotive, electricity and food, which were the most worked sectors.

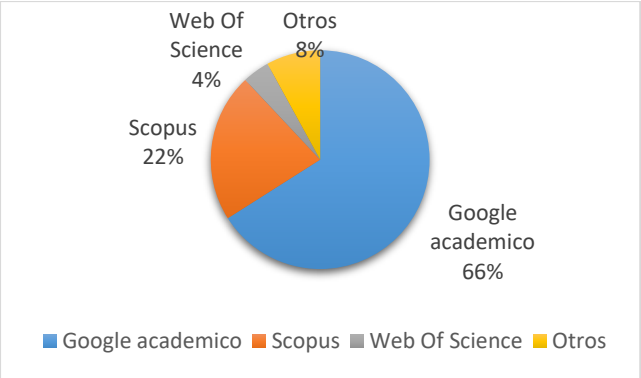
An analysis of the implementation of fuzzy logic and heuristic methods in the industrial sectors studied was also elaborated [18]. Finally, Hung, Medina, Comas, Hernandez and Medina (2014) expose various concepts of aggregate planning and its relationship with the environment of organizations in terms of their basic functions and relationship with business strategies. In addition, it performs a brief collection and description of aggregate planning strategies for problem-solving [19]. Therefore, the present review article has added value, as it focuses on analyzing the results of aggregate planning in the manufacturing industry and how they arrived. In addition, information was gathered on new factors and existing methods to solve problems related to aggregated operations planning.

According to the above, the article's objective is defined as a literature review of the context of aggregate operations planning, focused on the design and implementation of models in the manufacturing industry. Besides, we will analyze the sectors that have applied this knowledge to know the impacts, either in costs or profits of the companies, through the application of leveling, chase and mixed strategies. Furthermore, we hope to complement this review article with a practical analysis of the different solution methods (mathematical programming, simulation and heuristic methods) and the tools used as specialized software and their importance in the development and solution of aggregate planning problems in the industry. Likewise, we will analyze the industrial sectors in which the implementation and resolution of aggregate planning models have been carried out.

2. Method

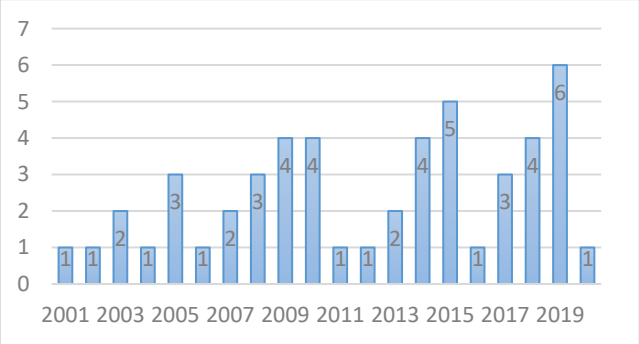
We consulted the following databases: Google Scholar, Web of Science and Scopus (Figure 1), where certain search equations were established based on aggregate operations planning, and production planning, in conjunction with: the manufacturing industry, manufacturing, and industrial process improvement.

Figure 1. Databases for obtaining bibliographic sources



We considered documents published from 2000 onwards (Figure 2). Moreover, we decided on papers based on applications of design and implementation of various strategies in sectors related to the manufacturing industry, which were supported by sources of general knowledge on aggregate operations planning.

Figure 2. Years of publication of selected documents



Analyzing each source allowed us to define the information to be extracted from each of them, using concepts and theories of aggregated operations planning.

3. Results

3.1 Strategies

Table 2. Strategies for operations planning

Strategy	%	References
Mixed	64,71	9, 23, 29, 30, 35, 40-43, 45, 47
Leveling	23,53	10, 20, 22, 34
Chasing	11,76	21, 47

The selection of the aggregate planning strategy must be appropriate for each industrial sector since each has requirements and restrictions for its transformation processes. However, in a general context, mixed strategies, including overtime, subcontracting, hiring or firing, are the most applicable, in addition to the other strategies, which are adapted to the industrial context (Table 2).

To implement the workforce leveling strategy, the total production must be met, employing measures such as overtime and relocation of labor during idle times [20]. Aggregate planning using chasing, can generate a series of consequences or assumptions on which it usually works, where it is analyzed having a constant labor force, that will end up in the need to resort to overtime when the production capacity is exceeded, on the other hand, if it works with labor reduction, it will lead to the realization of adjustments in production costs. Finally, it can be combined with the leveling strategy, which will allow inventory costs to be taken into account [21].

In many cases of operations planning, an analysis was made by comparison, where several strategies were used to find the one that yielded the best results and adapted to the industries. For example, in small sawmills, where the quality of labor is essential, due to the requirements of experience and knowledge of the industry, it is advisable to apply aggregate planning through a database, computer tools and professional capacity destined to generate positive results in business management. It was found that the best proposal was that of leveling where the labor force remained constant by adjusting inventories, yielding better results than the mixed and pursuit strategy, which will allow to continue with the quality of the workforce and avoid staff turnover [22].

3.2 Performance measures

Table 3. Performance measures

Performance measure	Components	%	Reference
Cost	Inventories Shortages Regular time Overtime Subcontracting Hiring and firing Environmental Social Raw Materials	79,41	1, 8-11, 20-23, 25, 26, 29-31, 34-36, 38, 40-44, 46-49
Profit		20,59	7, 27-28, 33, 39, 45, 50

The results is in Table 3, where the superiority of costs as a performance measure is evident. By utilizing the data on the forecasts and the standard production time, it is possible to continue with the aggregate planning process, establishing the associated costs [23]. These are generally represented by smoothing costs, inventories, shortages, regular time, overtime, and subordination [24]. For the solution of an aggregated planning model by linear programming, in which most cases take the costs as a performance measure, its objective function is the minimization of production planning costs [25]. Costs can be affected according to the strategy to be implemented. It depends on the special conditions of the manufacturing sector, according to the methodology of each of these strategies [9]. It was evidenced in [26], the inclusion of raw material costs together with the costs of the aggregate plan.

Profit is a performance measure that maximizes the difference between sales revenue and the total cost components [27]. The objective function is designed to maximize the profit at the end of the planning period. In addition, it is usually integrated with a model, the production variables, with those of financial management to achieve more effective decision-making [7].

With the new trends in social and environmental policies in the industry, we found the inclusion of environmental and social factors in the cost structure in more recent models of aggregate planning. Some

papers have compared conventional models of aggregate planning with those that consider sustainability factors, showing a decrease of 2% in profit, as seen in the case of the manufacturing industry of household appliances [28]. Furthermore, tax benefits are obtained in many countries by considering environmental and social factors in operation planning. For example, in Colombia, the hiring of disabled personnel is promoted, which positively influences companies' finances. In a particular case, an increase in cash flow of 40% was shown by having disabled labor [29]. It is observed the evolution of the industry towards an ideology of social responsibility, considering the influence of its operations on the environment and the society around them, so they are in need to allocate funds to supply aspects such as emissions control, operating taxes and contributions to programs and institutions beneficial to society.

3.3 Solution methods

Tabla 4. Solution methods

Methods		%	References
Mathematical programming	Linear Programming	24,13	9, 11, 23, 41, 43-45
	Multi-objective linear programming	20,69	1, 20, 25, 27-28, 34
	Linear programming-Fuzzy logic	17,24	8, 32-33, 35-36
	Mixed integer linear programming	17,24	29-30, 39, 47, 50
Simulation	Discrete events	6,90	37, 48
	Monte Carlo	6,90	10, 38
Heuristics	Trial and error	6,90	22, 42

According to the review carried out and the results specified in table 4, the high applicability of mathematical programming models is linear programming, which consists of elaborating an objective function, which in most cases is carried out to minimize total costs [20]. The solution using linear programming combines, controls and minimizes the most important resources a company has in the best way [9]. On the other hand, mixed integer linear programming allows the possibility of dealing with models of great difficulty in the manufacturing industry in multistate serial systems [25]. As in the refrigerator industry in Turkey, it was applied to optimize the manufacturing process, considering environmental and social sustainability [30]. In cases where handling more than one objective function is required, multiobjective mixed integer linear programming is a suitable alternative for its application in the solution of sophisticated and complex aggregate planning models [27]. Moreover, it can be adapted to not-so-common solution models, as in the cable industry, in which the solution was performed using transport models based on the Vogel approximation method, assigning 4% of the production to overtime, decreasing this factor by 2.9% compared to the initial model [31].

Fuzzy logic is applied in aggregate planning as one of the starting points of the model since it can be used as a tool for forecasting since it is a value with uncertainty [32]. In linear programming, it is used to manage the demand. It can represent a benefit or advantage for the analyst, working with fuzzy data with a certain degree of accuracy and security [8]. Applying tolerances for some constraints that require it of the linear programming model, its effects will be reflected in the level of satisfaction of the decision maker [33]. Sometimes fuzzy logic must be applied in multi-objective programming models, having more than one data with uncertainty [34]. For example, the application for the solution of an aggregate

planning model where demand, operating costs and capacities are uncertain data [35]. This will allow for choosing a production plan that best suits the variant market conditions, and production capacities, among other aspects [36].

The discrete event simulation model allows obtaining the plant's behaviour under changing production levels, working hours, inventories and distribution through the application of templates designed for its application [37]. On the other hand, the Monte Carlo simulation method is used to generate random demands, which will be used to understand the behavior of process variables such as inventory costs and missing units, since it generates several plans or events, in which the demand varies, where the best result of the total number of simulations is selected [38].

Trial and error heuristics are used to illustrate alternative plans and compare capacities, considering the demand, the labor and production and inventory background. This method finds regular production, overtime or subcontracting, which generates a search habit as a decision rule. The process is repeated by applying other alternatives to obtain several aggregated plans to choose the best solution [20].

The great advantage of the aggregate planning solution methods in the manufacturing industry is the flexibility of the proposed models, since they can be applied in different sectors, with only minor adjustments in the variables and restrictions [39].

3.4 Tools used

Table 5. Tools used in operations planning

Software	%	References
Excel	37,5	1, 10, 21-23, 38-39, 41, 46
Lingo	25	9, 11, 27, 33, 35, 42
WinQSB	12,5	20, 25, 40
IBM CPLEX- FICO Xpress Optimizer	12,5	45, 47, 49
GAMS	8,33	8, 43
Symphony	4,17	37

The application of software in aggregate planning is essential to solve the formulation of models by any methods used optimally. In the literature review, the application of the *Aggregate Planning* tool belonging to the WinQSB software was found, which allows obtaining a first optimal solution subject to subsequent changes of the model according to the analyst's criteria to get a better solution [40]. As for Excel, the implementation of *Solver* was reviewed for the resolution of linear programming models, through a straightforward design and registration of the information, feeding the models and allowing the determination of values of the objective function and decision variables [41]. As a result, Microsoft Excel helps to find a plan that meets the estimated demand and yields the solution of the minimum costs in a planning period [22]. On the other hand, Lingo was used to solving aggregate planning problems through mixed integer linear programming [42].

Moreover, this software presents a perfect interface to solve linear, integer and nonlinear programming problems [9]. For the solution of models with many variables and constraints, GAMS can be used, which can be linked to Excel employing Visual Basic coding, to generate an interface that allows displaying the results better [43]. Given the easy handling and access to Microsoft Excel, it was found as the most

used for the solution of aggregate planning models in the manufacturing industry, as shown in Table 5, allowing to obtain results with a high degree of accuracy to offer increased flexibility in the modeling of the information.

3.5 Industrial sectors

Table 6. Industrial sectors

Industry	%	References
Household appliances	16	8, 28, 30, 49
Food	12	20, 40, 44
Automotive	12	46-48
Textiles	12	10, 43, 50
Building Materials	8	27, 37
Forestry	8	22, 45
Metalworking industry	8	35, 41
Wiring	4	31
Cosmetics	4	38
Leather, footwear and leather goods	4	9
Furniture	4	42
Chemical processing	4	5
Toiletries	4	23

Aggregate planning of operations in the manufacturing industry has been implemented in a large number of companies and in various sectors, as detailed in Table 6, generally in search of minimizing costs, as in the food industry, where it was implemented and developed with WinQSB software, evaluating seven aggregate plans, of which they obtained the minimum cost in the seventh plan with an optimal value of $780,620,000 where they mixed the strategies of leveling and chasing [40]. Similarly, in a chocolate company where they managed to minimize costs for 10 product families, for which information on the optimal solution and the objective function could not be obtained due to the company's policies [44].

In specific cases, the company's objective is to maximize profits, where aggregate planning has made it possible to determine the production, subcontracting and inventory levels for each of the sawmills of a forestry company, supported by the use of FICO Xpress-Optimizer and CPLEX as a solution tool [45].

Aggregate planning can be focused on determining general aspects of a production process, as in a company of the automotive sector that minimice the costs, and find the appropriate use of its production capacity, inventory levels, subcontracting and overtime, considering process limitations and company policies, where the mixed strategy was defined as the most appropriate, yielding an optimal production of 1450 prod/month [46]. Similarly, companies in the same sector have worked in highly variable environments to minimize costs, where the model was solved by applying mixed integer linear programming [47].

In addition to linear programming, in the automotive sector, simulation methods have also been used, specifically using discrete events, for aggregate planning, with a very complex model consisting of 5 stages of 12 final products and 16 components, where the objective was the inventory costs, were utilizing ten simulations they obtained a customer service level of 4% and inventory of 3% [48].

Optimizing and improving aggregated operations planning models are essential for efficient business management. For example, a metal-mechanic industry implemented the strategies of chasing, overtime

and inventory levels to achieve a 7.4% reduction in labor and hiring costs, generating a positive impact of savings of approximately $2,083,813 [41].

In the household appliances manufacturing sector, models have been developed focused on sustainability, which takes into account environmental and social aspects, to reduce environmental pollution and ensure the social welfare of employees, where a mixed integer linear programming model was performed that took into account these aspects, influencing the increase in costs of 4.47% and 2.47% for environmental and social factors, respectively [30]. Another approach in this sector was to maximize the profits generated in a period taking into account restrictions based on the remanufacturing processes [49].

In the application of aggregate planning models, there are cases in which restrictions are established by management, customers or that are special to the industrial sector treated, such as the footwear sector, since the solution was made by linear programming, which served to reduce production costs and increase process productivity, keeping labor at a stable level and resorting to the variation of inventories according to the needs of each season [9]. A similar case is presented in the furniture industry, in which changes in the labor force must be managed with caution, where priority is given to the mobility of personnel in jobs, rather than hiring and firing, in which aggregate planning was applied to reduce costs by 23% [42]. Aggregate planning can be implemented in different production methods, as in the textile sector, under a make-to-order philosophy, for 28 families of garments, where it was possible to maximize profit and obtain the optimum quantities to manufacture 11162 garments in the typical workday, 3120 in overtime and 3648 in maquila [50]. This allows visualizing the flexibility and adaptability of aggregate planning and its solution methods to the particular requirements of the various manufacturing industries and the importance of its application for business decision-making according to its solution by several methods.

4. Conclusions

This paper visualizes how aggregate planning is designed, modeled, solved and applied in the manufacturing industry, having references of application in 13 recognized industrial sectors. This researches obtained an optimal combination between production capacity, inventory levels and labor, which is carried out for a planning process of between 3 to 18 months, with various strategies that are adapted to each of the contexts of the manufacturing sectors such as leveling, chasing and mainly mixed strategies that are the most used with 64.71% of the articles analyzed, since allows taking aspects of the others, which are used to structure an appropriate model for each industry. Through this production planning method, the relevant information is obtained for decision-making in the manufacturing industry, allowing the management of process variables, as it is more convenient for the company, taking into account the aspects and rigorousness existing within the corresponding industrial sector and demonstrating the flexibility of this technique. This review article presents an alternative for business people or students to know and analyze the behavior and variability of the application of aggregate planning in the manufacturing industry.

We found in the review that costs are the most used performance measure in the various manufacturing industries, with 79.41% of the articles found. Mathematical programming is the most applied solution method in the research to address the problems of the manufacturing industry with 79.3%, because it is a method that has great flexibility and adaptability in different sectors, just by adjusting the decision variables and constraints, according to the needs and requirements that affect the manufacturing industry, such as business policies, customer demands, demand behavior, uncertainties of variables and

aspects of each industrial sector. Depending on the above aspects, a decision must be made between linear programming, mixed integer, multiobjective or the application of fuzzy logic to subsequently perform the solution of the method with the help of specialized software, such as Microsoft Excel, through its Solver tool, that was the most used with 37.5% of the papers since it is easy to use and understand software for the design and development of any model.

The evolution of the operations planning in the industry is observed when adapting to the current environmental and social conditions since recent inclusions of these aspects in the proposed models were found, which allowed determining the impact of environmental and social aspects on the profit and production costs of manufacturing industries, within the framework of the methodology of corporate responsibility and sustainability. Therefore, a recommendation is made to future literature reviews or scientific articles on aggregate planning of operations to consider environmental and social factors in their research since they are currently a fundamental part and have a significant impact on organizations' finances.

References

[1] R. S. Quintero, A. Correa Espinal, and J. A. Aristizábal, "Un enfoque de analisis multiobjetivo para la planeación agregada de producción," 2004. Accessed: Apr. 29, 2020. [Online]. Available: https://www.redalyc.org/pdf/496/49614104.pdf.

[2] R. Chase, R. Jacobs, and N. Aquilano, *Administracion de Operaciones*. 2007.

[3] J. Humberto and T. Acosta, "Procedimiento para la planeación agregada en la pequeña y mediana industria manufacturera Aplicación al sector industrial colombiano (planeación agregada de producción)." Accessed: May 02, 2020. [Online]. Available: https://dialnet.unirioja.es/servlet/articulo?codigo=4797394.

[4] R. Vergara, "Desarrollo de los procesos de planeación y programación de la producción en el sector manufacturero de la PYME en Bogotá," *Av. Investig. en Ing.*, vol. 5, no. 5, pp. 69–78, 2006.

[5] M. Brandenburg and G. J. Hahn, "Sustainable aggregate production planning in the chemical process industry - A benchmark problem and dataset," *Data Br.*, vol. 18, pp. 961–967, 2018, doi: 10.1016/j.dib.2018.03.064.

[6] "Manual de dirección de operaciones. (2005) - Buscar con Google." https://www.google.com/search?q=Manual+de+dirección+de+operaciones.+(2005)&oq=Manual+de+dirección+de+operaciones.+(2005)&aqs=chrome..69i57.566j0j4&sourceid=chrome&ie=UTF-8 (accessed Jun. 13, 2020).

[7] O. Boiteux, A. Lusa-Garcia, A. Corominas, and C. Martinez-Costa, "Planificación agregada de la producción, la plantilla, el tiempo de trabajo y la tesorería," *redalyc.org*, vol. 5, no. 3, pp. 1697–9818, 2009, doi: 10.3926/ic.2009.v5n3.p259-277.

[8] M. D. A. Serna, C. V. Rodríguez, and H. G. Montoya, "Modelización difusa para la planificación agregada de la producción en ambientes de incertidumbre," *DYNA*, vol. 77, no. 162, pp. 397–409, 2010.

[9] J. P. Reyes Vasquez and C. G. Molina Velis, "Plan Agregado de Producción Mediante el Uso de un Algoritmo de Programación Lineal: Un caso de Estudio," *Rev. Politécnica*, vol. 34, no. 1, pp. 1–7, 2014, [Online]. Available: http://www.revistapolitecnica.epn.edu.ec/ojs2/index.php/revista_politecnica2/article/view/254.

[10] N. P. Huertas Colmenares, "Planeación, programación y control de la producción en modas," 2013. Accessed: Jun. 15, 2020. [Online]. Available: http://repository.unilibre.edu.co/handle/10901/9435.

[11] A. Hafezalkotob, S. Chaharbaghi, and T. M. Lakeh, "Cooperative aggregate production planning: a game theory approach," *J. Ind. Eng. Int.*, vol. 15, no. s1, pp. 19–37, 2019, doi: 10.1007/s40092-019-0303-0.

[12] A. Legarda-Zaragüeta, A. Hidalgo-Nuchera, and J. B. Lidoy, "La importancia de la industria manufacturera en el crecimiento y la competitividad de un país," *Dyna*, vol. 89, no. 4, pp. 377–

381, 2014, doi: 10.6036/7078.
[13] R. Horta, L. Silveira, and M. Camacho, "Competitividad e innovación en la industria manufacturera en el Uruguay," 2015. http://www.scielo.org.ar/scielo.php?script=sci_arttext&pid=S1850-00132015000100003&lng=en&tlng=en&SID=8EmivyB1xfkTpcNpKHA (accessed Jun. 13, 2020).
[14] C. Berra Barona and M. Ramirez Ramirez, "Análisis del sector manufactura en México," *Criterio Libr.*, vol. 18, no. 31, pp. 167–182, 2019, doi: 10.18041/1900-0642/criteriolibre.2019v18n31.6135.
[15] C. Amézquita, "Manufacturing Sector in Colombia (1995-2005)," *Rev. la Fac. Ciencias Económicas*, vol. XVI, no. 2, pp. 61–78, 2008.
[16] M. Lambrecht *et al.*, "The dynamics of aggregate planning," *Prod. Plan. Control*, vol. 14, no. 6, pp. 497–516, Sep. 2003, doi: 10.1080/0953728031000162196 7.
[17] O. D. Boiteux, A. Corominas, and A. Lusa, "La Planificación Agregada como Instrumento Integrador de las Áreas Funcionales de la Empresa : Estado del Arte y Perspectivas," *Int. Conf. Ind. Eng. Ind. Manag.*, pp. 389–395, 2007, [Online]. Available: Amaia.Lusa@upc.edu.
[18] C. R. Suares, "Planeación agregada de la producción en el sector de manufactura. una revisión del estado de arte.," 2017, Accessed: Apr. 29, 2020. [Online]. Available: http://repository.ucc.edu.co/handle/20.500.12494/8072.
[19] I. Manuel, H. Varela, C. A. M. León, and C. R. C. Rodríguez, "Planeación Agregada : El Concepto Y Las Estrategias," vol. 2014, no. c, 2014.
[20] R. R. Gómez, R. C. Castro, H. G. Martín, and W. S. Castro, "Modelo para la planeación agregada en empresas dedicadas a la reparación de motores diesel utilizados en la industria azucarera cubana," *Cent. Azúcar*, vol. 32, no. 1, pp. 85–92, 2005, [Online]. Available: https://centroazucar.uclv.edu.cu/media/articulos/PDF/2005/1/14.pdf.
[21] E. Oey, W. A. Wijaya, and S. Hansopaheluwakan, "Forecasting and aggregate planning application - A case study of a small enterprise in Indonesia," *Int. J. Process Manag. Benchmarking*, vol. 10, no. 1, pp. 1–21, 2020, doi: 10.1504/IJPMB.2020.104229.
[22] S. Rodrigo Del Solar, C. Iván Chacón, and D. Mauricio Ponce, "Plan agregado de producción en barracas madereras. Estudio de caso para una pequeña industria," *Maderas Cienc. y Tecnol.*, vol. 10, no. 2, pp. 77–92, 2008.
[23] S. Y. Bello Hernández and D. F. Zambrano Jiménez, "Design of a system for planning, programming and control of production in Productos," 2013. Accessed: May 02, 2020. [Online]. Available: https://revistas.udistrital.edu.co/index.php/tekhne/article/view/8938.
[24] S. Nahmias, *Análisis de la producción y las operaciones, 5ta Edición*. 1979.
[25] J. Leonardo and R. González, "La programación mixta como herramienta para la solución de problemas de Planeación Agregada Multietapas," *Ing.*, vol. 8, no. 1, pp. 29–35, 2003, doi: 10.14483/23448393.2848.
[26] J. Torres Acosta, "Planeación Agregada de Costos: Procedimientos para la PYME Manufacturera Colombiana," *Ingeniería*, vol. 7, no. 1, pp. 6–10, 2002, doi: 10.14483/23448393.2263.
[27] C. Gomes Da Silva, J. Figueira, J. Lisboa, and S. Barman, "An interactive decision support system for an aggregate production planning model based on multiple criteria mixed integer linear programming," *Omega*, vol. 34, pp. 167–177, 2006, doi: 10.1016/j.omega.2004.08.007.
[28] S. A. B. Rasmi, C. Kazan, and M. Türkay, "A multi-criteria decision analysis to include environmental, social, and cultural issues in the sustainable aggregate production plans," *Comput. Ind. Eng.*, vol. 132, no. April, pp. 348–360, 2019, doi: 10.1016/j.cie.2019.04.036.
[29] R. Eia, "Plan Agregado De Producción Con Personal En Situación De Discapacidad," *Rev. EIA*, no. 23, pp. 175–187, 2015, doi: 10.24050/reia.v12i23.731.
[30] M. Türkay, Ö. Saraçoğlu, and M. C. Arslan, "Sustainability in supply chain management: Aggregate planning from sustainability perspective," *PLoS One*, vol. 11, no. 1, pp. 1–18, 2016, doi: 10.1371/journal.pone.0147502.
[31] M. Sultana, S. Shohan, F. S.-I. J. of Managing, and undefined 2014, "Aggregate planning using transportation method: a case study in cable industry," *academia.edu*, Accessed: May 02, 2020. [Online]. Available: http://www.academia.edu/download/61739950/120200110-79949-

1t88f83.pdf.
[32] E. N. Escobar-Gómez, J. J. Díaz-Núñez, and L. F. Taracena-Sanz, "Modelo para el ajuste de pronósticos agregados utilizando lógica difusa," *Ing. Investig. y Tecnol.*, vol. 11, no. 3, pp. 289–302, 2010, doi: 10.22201/fi.25940732e.2010.11n3.025.
[33] M. Arango, "Aplicaciones de la logica difusa en la cadena de suministros," *Avances en sistemes e informatica*, vol. 5. pp. 117–126, 2008.
[34] M. Mezghani, T. Loukil, and B. Aouni, "Aggregate planning through the imprecise goal programming model: Integration of the manager's preferences," *Int. Trans. Oper. Res.*, vol. 19, no. 4, pp. 581–597, 2012, doi: 10.1111/j.1475-3995.2012.00844.x.
[35] R. C. Wang and T. F. Liang, "Applying possibilistic linear programming to aggregate production planning," *Int. J. Prod. Econ.*, vol. 98, no. 3, pp. 328–341, 2005, doi: 10.1016/j.ijpe.2004.09.011.
[36] R. Y. K Fung, J. Tang, and D. Wang, "Multiproduct Aggregate Production Planning With Fuzzy Demands and Fuzzy Capacities," *Syst. HUMANS*, vol. 33, no. 3, 2003, doi: 10.1109/TSMCA.2003.817032.
[37] X. Tian, Y. Mohamed, and S. Abourizk, "Simulation-based aggregate planning of batch plant operations," *Can. J. Civ. Eng.*, vol. 37, no. 10, pp. 1277–1288, 2010, doi: 10.1139/L10-071.
[38] B. M. Vargas and L. B. Urrea, "Diseño de un modelo de planificación agregada de la producción mediante programación lineal, en la línea de compacto, considerando análisis de capacidad y," *repository.javeriana.edu.co*, Accessed: May 02, 2020. [Online]. Available: http://repository.javeriana.edu.co/handle/10554/44546.
[39] V. Uluçamlı, "Aggregate production planning model based on mixed integer linear programming," 2010. Accessed: May 02, 2020. [Online]. Available: http://dspace.marmara.edu.tr/handle/11424/1608.
[40] P. Medina Varela, J. Restrepo Correa, and E. Cruz Trejos, "Plan de producción para la compañía de helados 'NATA,'" *Sci. Tech.*, vol. 3, no. 43, pp. 311–315, 2009, doi: 10.22517/23447214.2261.
[41] A. J. Caicedo-Rolón, A. M. Criado-Alvarado, K. J. Morales-Ramón, P. Planeación Estratégica Estadísticas, and K. J. Morales-Ramón E, "Modelo matemático para la planeación de la producción en una industria metalmecánica Mathematical model for production planning in a metalworking industry," *Sci. Tech. Año XXIV*, vol. 24, no. 03, Accessed: May 02, 2020. [Online]. Available: http://201.131.90.33/index.php/revistaciencia/article/view/16031.
[42] I. Madanhire and C. Mbohwa, "Aggregate production planning framework in a multi-product factory," *Int. Conf. Ind. Eng. Oper. Manag.*, pp. 2531–2540, 2015, [Online]. Available: https://ujcontent.uj.ac.za/vital/access/services/Download/uj:5163/CONTENT1.
[43] E. A. Campo, J. A. Cano, and R. A. Gómez-Montoya, "Linear programming for aggregate production planning in a textile company," *Fibres Text. East. Eur.*, vol. 26, no. 5, pp. 13–19, 2018, doi: 10.5604/01.3001.0012.2525.
[44] Z. Düzgit *et al.*, "Production Planning at a Chocolate Company: A Two-Phase Approach by Aggregation," *Lect. Notes Mech. Eng.*, vol. 1, pp. 169–181, 2020, doi: 10.1007/978-3-030-31343-2_15.
[45] L. Pradenas, C. Alvarez, and J. A. Ferland, "A Solution for the Aggregate Production Planning Problem in a Multi-Plant, Multi-Period and Multi-Product Environment." Accessed: May 02, 2020. [Online]. Available: https://www.iro.umontreal.ca/~ferland/Publications/Acta_Ferland.pdf.
[46] P. Ryszard, A. Katarzyna, and Z. Wladyslaw, "Optimization of the Medium-Term Production Planning in the Company-Case Study," 2019. https://books.google.com.co/books?id=a4teDwAAQBAJ&pg=PA369&lpg=PA369&dq=Optimization+of+the+medium-term+production+planning+in+the+company-case+study&source=bl&ots=DpU7PDbozy&sig=ACfU3U1fxUYyGkPSeWMZMnHtuESGvyIqaA&hl=es&sa=X&ved=2ahUKEwjGkaeQwazqAhUGZd8KH (accessed Jul. 01, 2020).
[47] E. Demirel, E. C. Özelkan, and C. Lim, "Aggregate planning with Flexibility Requirements Profile," *Int. J. Prod. Econ.*, vol. 202, pp. 45–58, 2018, doi: 10.1016/j.ijpe.2018.05.001.
[48] M. Gansterer, "Aggregate planning and forecasting in make-to-order production systems," *Int. J. Prod. Econ.*, vol. 170, pp. 521–528, 2015, doi: 10.1016/j.ijpe.2015.06.001.
[49] P. Taylor, A. Corominas, A. Lusa, and J. Olivella, "A manufacturing and remanufacturing

aggregate planning model considering a non-linear supply function of recovered products," no. April 2013, pp. 37–41, 2011.

[50] G. Arredondo Ortega, K. V. Ocampo Jaramillo, J. P. Orejuela Cabrera, and C. A. Rojas Trejos, "Modelo de planeación y control de la producción a mediano plazo para una industria textil en un ambiente make to order," *Rev. Ing. Univ. Medellín*, vol. 16, no. 30, pp. 169–193, 2017, doi: 10.22395/rium.v16n30a9.

Appendix A. An example appendix

Authors including an appendix section should do so after References section. Multiple appendices should all have headings in the style used above. They will automatically be ordered A, B, C etc.

A.1. Example of a sub-heading within an appendix

There is also the option to include a subheading within the Appendix if you wish.

Makalenin Türkçe başlığı buraya yazılır….

Özet

Türkçe özet.

Anahtar sözcükler: anahtar sözcükler1; anahtar sözcükler2; anahtar sözcükler3

AUTHOR BIODATA

Insert here author biodata**.**