Proceedings of the International Conference on Industrial Engineering and Operations Management
Manila, Philippines, March 7-9, 2023

Aggregate Production Planning with Organizational Learning and Social Sustainability Considerations – Current Gaps and Future Opportunities

Mostafa Tarek, Ahmad E. Elhabashy, Hadi Fors, and M. Hamdy Elwany
Production Engineering Department
Alexandria University
Alexandria 21544, Egypt
mostafa.tarek@alexu.edu.eg, ahmadelhabashy@alexu.edu.eg,
hadifors@alexu.edu.eg, hamdy.elwany@alexu.edu.eg

Abstract

Enhancing industrial organizations' responsiveness to market fluctuations is essential to survive current global supply chain challenges. Better responsiveness can be attained through robust and real-time production planning, especially on the tactical level through Aggregate Production Planning (APP) activities. A key variable in APP is workforce productivity enhancement. However, the dynamic nature of the workforce raises concerns about productivity improvement initiatives. To address this issue, the incorporation of organizational learning and social sustainability into APP has received significant attention from megacorps looking to increase competitiveness. This literature review assesses the prevalence of workforce productivity and social sustainability considerations in the APP problem. The review found that there is a limited number of studies that consider organizational learning in APP, and more research is needed to address the resilience of organizational learning evaluation models. Additionally, there is a lack of studies that focus on social sustainability measures in APP. Finally, it was observed that metaheuristic approaches are commonly used to solve complex APP problems, with genetic algorithms, harmony search algorithms, and simulated annealing being the most frequently employed methods. More research is needed to explore the use of other metaheuristic approaches and to assess their effectiveness in solving APP problems.

Keywords
Aggregate Production Planning, Organizational Learning, Social Sustainability, Workforce, Metaheuristic

1.Introduction
Aggregate Production Planning (APP) is the medium-term capacity planning that determines the production plans required to meet customer demands (Sakallı et al. 2010). The APP problem generally aims to find the ideal production quantity considering inventory capacity and lowering cost employment level throughout a finite planning horizon (Cheraghalikhani et al. 2019). APP's primary objective is to manage plant capacity to fit demand while considering lowering the costs and presence of limited financial resources (Khaled et al. 2022). A typical APP problem involves simplification of considered influencing factors, such as machine failures, workforce productivity, backorders, setup time, changeover time, and delivery lead time.

In today's challenging industrial environment, with the scarcity of raw materials, growing world demand, and environmental regulations, sustainability has become a top priority throughout the production processes. In addition, unexpected events (for example, COVID-19) causing disruptions to the global economy made industrial firms adopt and change plans and policies related to employee management. Such policies and plans aim for better workforce performance and a healthy, socially sustainable working environment that ensures work-life balance (Kumar & Suresh 2009; Türkay et al. 2016). In this article, the term workforce includes all white and blue-collar staff and all other employees interfering with the product/service.

Sustainability-based Aggregate Production Planning (SAPP) is derived from the commonly accepted definitions of sustainable development, sustainable manufacturing, and production planning. Zarte et al. (2022) define SAPP as "the planning of production activities to achieve conventional (economic) production goals, ensuring the enterprises'

operation. Moreover, other sustainability goals must be achieved, avoiding, reducing, or compensating environmental damages and social issues". Introducing sustainability measures among these activities, including APP, require proper redesigning of organizational planning levels.

Workforce learning and experience evaluation are aspects with great impact on APP as they affect the actual production performance directly, and such aspects have not gained much attention in recent APP literature (Hahn & Brandenburg, 2018; Mehdizadeh et al. 2018). Industries, such as textiles, construction, automotive, customer service, retail, and healthcare, that depend on workforce performance will be the most beneficial from integrating experience evaluation with APP. Considering the organizational learning effect as the learning effect of a larger group of individuals within the same organization is with great influence on "converging" sustainability goals, by enhancing the efficiency and competence of individuals. Employees at all levels within the organization are continuously encouraged to develop their abilities and technical knowledge (Silveira et al. 2013).

With the importance of having a sustainable APP and the constantly changing industrial environment in terms of workforce resources' availability, the objective of this article is to assess the prevalence of workforce productivity and social sustainability considerations in the APP problem. More specifically, this objective will be achieved through reviewing the related literature that considers 1) modelling organizational learning impact on workforce productivity, 2) adopting sustainability measures that ensure proper human resource utilization, and, finally, 3) aiming for more robust modelling and solution approaches that incorporate real-world production system variables.

1. Review Methodology

A literature review was conducted using the Scopus (Elsevier) database up to June 2022. This study sets out to answer the following questions:

1) How far is organizational learning (the "Learning Curve" effect) impacting the APP problem?
2) What is the current status of workforce-related aspects (social sustainability) in APP problems? and
3) What modelling and solution approaches can handle such problem complexity?

The first step in this review was to start searching articles by defining the research focus that is aligned with the mentioned questions, where three tracks were defined. The first one is Aggregate Production Planning, the second one is workforce efficiency evaluation (organizational learning), and the last one is social sustainability. The chosen keywords for the first track were "Aggregate Production Planning" and "Aggregate Planning"; for the second track, were "Organizational learning", "learning rate", and "learning curve"; and for the third track, were "Social" and "Social Sustainability". In addition, more keywords were used to investigate solution approaches, including but not limited to "Meta-Heuristic" and "Metaheuristic". Hence, the following section will discuss the following aspects: 1) Descriptive findings of organizational learning impact in APP, SAPP focusing on workforce social-related aspects, and APP problem modelling and solution approach. 2) Numerical findings discussing some statistical insights regarding the conducted review. Finally, summarizing the findings, opportunities, and highlighting the limitations is presented in the last section.

2. Review Findings and Results

Descriptive Findings

Organizational Learning in Aggregate Production Planning (APP)

Much effort must be focused on improving workforce productivity and utilization in aiming for a higher responsive manufacturing system. One invaluable part of achieving this goal is effective workforce performance management, particularly the concept of workforce experience evolution. The evaluation of workforce experience is based on the learning curve phenomenon. This concept's impact is considered in many applications, including APP, workforce flexibility, workforce assignment, impact on inventory management, impact on operations cost, and production capacity planning (Attia et al. 2022).

The use of learning curve aims to relate the labor performance on a specific task to the number of repetitions of that task. The incorporation of such a phenomenon in planning activities strongly elevates the utilization of capacities in many real-practical situations. In practice, the learning curve can be considered through various levels and concepts such as individual learning, group learning, and organizational learning. The individual learning concept reflects the increase in capacity that contributes to the organization's success by a specified worker. Group learning considers individual learning concept as well as knowledge transfer between workers in a group; whereas organizational learning

captures the improvement of the organization's performance on a specific product that was produced by the contribution of the whole workforce rather than a specified individual or group. Nevertheless, when considering products manufactured by incorporating several production units of the workforce on a tactical level, organizational learning curves are more effective, as the only available data will be aggregate planning and performance data (Levin & Globersont 1993).

Table 1 presents the search statements for two queries used to investigate the consideration of workforce experience evaluation in APP and how such evaluation could impact APP outcomes. Search results distinguishing APP and the learning curve effect outlined a significant limitation in the number of results.

Table 1. Scopus search statement and results of APP with learning effect considerations

	Search Statement	Total Results
1	TITLE-ABS-KEY ("Aggregate Production Planning" OR "Aggregate Planning") AND TITLE-ABS-KEY ("Learning Curve" OR "Learning Rate")	10
2	TITLE-ABS-KEY ("Aggregate Production Planning" OR "Aggregate Planning") AND ALL ("Organizational learning" OR "learning rate" OR "learning curve")	33

The first query resulted in 10 documents, and only 8 of them could be considered relevant. Unexpectedly, the topic of organizational learning in APP has been handled since 1976, aiming to configure an optimal aggregate schedule under productivity change by constant learning curve estimates (Ebert 1976). Moreover, demand and productivity change were considered according to the learning curve impact (Khoshnevis 1979). An analysis of models that considers productivity improvement in aggregate production scheduling and workforce planning problem indicated insufficiency of the existing models as they divide the productivity improvement effect by addition and reduction of constant rates (Khoshnevis et al. 1982). Furthermore, a Mixed Integer Linear Programming (MILP) model was used to identify the optimal mix of internal and external technical resources to achieve the most suitable strategic expertise mix (Gagnon & Krasner 1990). Chakravarty et al. (1992) expressed the labor learning curve effect on production rate as a capacity constraint that could be increased with time (experience development). Despite the early consideration of such phenomena, the APP problem was not considered adequately with productivity change by learning curve incorporation except in the case study of Attia et al. (2022).

The novel case study by Attia et al. (2022), which illustrated and modelled the organizational learning effect on the APP problem, was successful in considering the workforce learning curve to manage production cost efficiently. Their proposed model successfully reduced production costs by an average of 6.3%, and such minor improvement engendered a massive cost saving of 17.3 million Egyptian pounds in terms of monetary value. Thus, considering the organizational learning effect would be beneficial for workforce-dependent production systems in reducing production costs (Attia et al. 2022).

To further investigate the learning curve consideration in the APP problem, a second query was performed through changing the learning keywords query string in the first query to ALL, while adding "organizational learning" with the aim of exploring the number of results that included these words. This search statement resulted in 33 documents, which included the previous query's 10 results as well. This limited number of results again confirms the limitation indicated by the previous query's articles and highlights the necessity of further exploration of the learning curve effect on the aggregate production problem.

In addition, it was observed from both queries that the learning curve models could be classified into single-variable or multi-variable models, where multi-variable models can accommodate factors that would influence how fast, how far, and how well a worker learns within a specified horizon (Attia et al. 2016). Future research in this area could be enriched by distinguishing appropriate learning curve evaluation variables and studying the impact of these variables on production rates, inventory levels, and workforce requirements.

2.1.1 Sustainable Aggregate Production Planning (SAPP)

In this fast-paced challenging market, an enormous amount of internal and external variables influences the entire production system's competitiveness. In workforce-dependent industries, significant concerns have been raised in

recent years regarding workforce aspects related to the social pillar of sustainability, such as social distancing, overtime working hours, employee satisfaction, training of the temporary workforce, job security, and employee safety (Khaled et al. 2022). In addition, the substantial global aspiration to force sustainability restrictions through all attributes of resources in the industry adds more sophistication to the planning activities throughout the entire supply chain (Rasmi et al. 2019).

According to the recent review by Khaled et al. (2022), most sustainability case studies in production planning focus on energy parameters. Moreover, recent studies stated that the number of case studies on production planning problems that simultaneously consider economic, environmental, and social pillars together is limited, and that among all sustainability pillars, social sustainability is the least considered pillar in this field, either as a single pillar or when integrated with other pillars (Khaled et al. 2022; Türkay et al. 2016).

Table 2. Scopus search statement and results of SAPP

Search Statement	Total Results
TITLE-ABS-KEY (“Aggregate Production Planning” OR “Aggregate Planning”) AND TITLE-ABS-KEY (“Social” OR “Social Sustainability”)	18

Table 2 shows the results of the search statement used to explore the research trend of social sustainability within the APP problem, confirming the limitation highlighted by previous researchers. A limited number of results appeared when searching for social sustainability consideration as a single pillar, specifically in the APP problem. Reviewing the 18 documents, it was found that only 6 of them are relevant to the APP problem, including 1 review paper, as discussed next.

Rasmi et al. (2019) developed a multi-objective APP model that addresses economic, environmental, cultural, and social sustainability pillars with more focus on the social aspect that is infrequently addressed according to their literature. They established an exact solution by applying Multi-Objective Mixed-Integer Linear Programming (MOMILP) on a numerical case study of a home appliance manufacturer. The authors also indicated that for a minor decrease in profit by 2%, the manufacturer was able to achieve high performance in non-economic factors of SAPP. Hahn et al. (2018) introduced a decision support system applied to the chemical process industry to select optimum production routing that ensures improved capacity utilization while considering the reduction of carbon emissions and unnecessary overtime working hours. Saracoglu et al. (2015) considered economic, environmental, and social pillars in APP, aiming to fill the gap in SAPP literature. Their model considered employee job security, employee health, work-family balance, and customer satisfaction as social aspects. They concluded that achieving improvement in social and environmental aspects will cause losses from the economic side.

In order to formulate social sustainability measures throughout APP modelling, the reviewed results consider quantitative variables limited to working hours, overtime hours, and hiring and firing strategies, while qualitative measures are not considered adequately (Rasmi et al. 2019; Türkay et al. 2016). Hence, additional articles considering social sustainability in general were briefly surveyed to explore further measures of social sustainability. Two sets of qualitative measures were considered by Kim & Kim (2012), which are safety and history. The safety set includes three sub-sets containing employee health status, violation status, and training status. The history set includes two sub-sets stating employee experiences and skill matrix. In addition, Khokhar et al. (2020) suggested much more general dimensions of workforce issues to be considered in manufacturer social sustainability, such as organizational commitment to management, occupational safety and health management, wages, labor rights, educational training, and worker welfare. Thus, further investigation of the convenient set of social APP workforce-related measures based on industry type, organization structure, and working environment is needed.

Solution Approaches and Modeling Techniques

The incorporation of APP with the intermixed nature of human learning evaluation and social sustainability entails a large-scale multiple conflicting objectives problem. In addition, real practice factors such as multi-product; uncertainty in demand, lead times of raw material, spare parts, and maintenance time; product price functions; and learning effect (dynamic workforce capacity) can convert APP models into a nonlinear sophisticated problem (Jamalnia et al. 2019; Kumar Badhotiya et al. 2018). In practical settings, such a model is computationally challenging and time-consuming. Thus, a novel approach to handle this complex problem is needed. According to the future research suggestions by Khaled et al. (2022), an efficient method to deal with these effortful models is to recourse to metaheuristics.

Table 3. Scopus search statement and results for APP meta-heuristic solution approaches

Search Statement	Total Results
TITLE-ABS-KEY ("Aggregate Production Planning" OR "Aggregate Planning") AND ALL ("Meta-Heuristic" OR "Metaheuristic")	21

Table 3 presents the search statement used to cover the use of metaheuristics as a solution approach for the APP problem. According to the limited number of results that consider metaheuristics as the main solution approach, despite the availability of enormous approaches, it can be claimed that applying such methodologies needs intensive future research to apply other metaheuristic approaches and to study their significance in solving such dynamic planning problems.

The search results, which consider only metaheuristics approaches in solving APP problems particularly, are generally limited in number. Some articles are considering either hybridized solution models or modified algorithms aiming to improve algorithm solution searching and initiation inputs. Some of the base approaches found in the results include Genetic Algorithm (GA) with its moderations (Goli et al. 2019; Hossain & Islam 2018; Mehdizadeh et al. 2018; Nobari et al. 2018; Zaidan et al. 2019), Harmony Search algorithm (HSA) and its moderations (Abu Bakar et al., 2016; Hossain & Islam, 2018), Tabu Search (TS) (Mehta et al. 2018), Simulated Annealing (SA) algorithm and its moderations (Abu Bakar et al. 2016; Kalaf et al. 2021; Kaveh & Dalfard 2014; Mehta et al. 2018; Zaidan et al. 2019), Bee Algorithm (BA) (Luangpaiboon & Aungkulanon 2013), and Particle Swarm Optimization (PSO) and its moderations (Kalaf et al. 2021; Mehta et al. 2018).

Figure 1 summarizes the percentage of frequencies of different metaheuristic solution approaches mentioned in the reviewed results, showing a larger interest in adopting GA, HSA, SA, and their hybridizations or moderations. The figure also shows other metaheuristic approaches that have been employed, such as Imperialist Competitive Algorithm (ICA) (Nobari et al. 2018), Invasive Weed Optimization Algorithm (IWO) (Goli et al. 2019), and the Simplex Downhill (SD) (Zaidan et al. 2019).

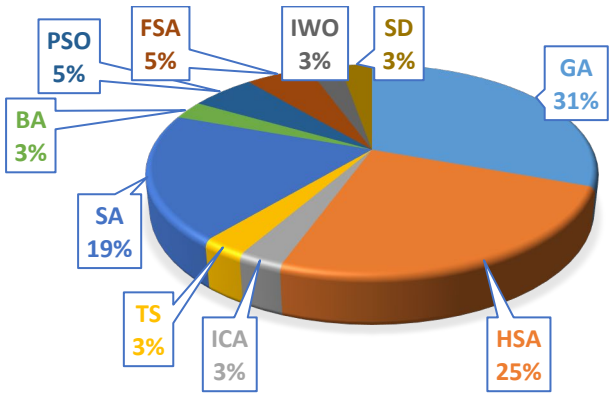

Figure 1. Frequencies of Metaheuristic approaches in the literature

Furthermore, most APP problems in the resulting articles are modelled as multi-objective problems. The modelling techniques frequencies is illustrated in Figure 2 and include Multi-objective linear programming (MOLP) (Zaidan et al., 2019), Multi-objective mixed integer linear programming (MO-MILP) (Goli et al. 2019), Mixed integer linear programming (MILP) (Baykasoglu & Gocken 2010; Kaveh & Dalfard, 2014), Mixed integer non-linear programming (MINLP) (Nobari et al. 2018), Linear Programming (LP) (Hahn & Brandenburg, 2018; Kalaf et al. 2021) and Possibilistic Linear Programming (PLP) (Hossain & Islam 2018). As shown in the figure, MILP based techniques are the mostly used modelling technique.

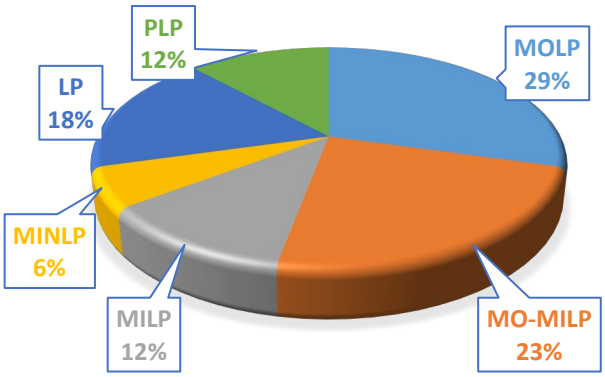

Figure 2. Frequencies of Modelling Techniques in the literature.

One noteworthy publication by Guzman et al. (2022) presented a holistic systematic review of models and algorithms applied to production planning problems that covered relevant articles from the years 2000 to 2020. They stated that MILP is the most widely used modelling approach, confirming our finding. They also found that complex models that use MILP as the modelling technique applied heuristic and metaheuristic algorithms to solve them. They concluded that the interoperation of mathematical models with metaheuristic or heuristic algorithms had been demonstrated to give good results for complex, multi-objective, and conflicting models.

In addition, Khaled et al. and Kumar Badhotiya et al. (2022; 2018) found that, for large complex problems, stochastic modelling and metaheuristics approaches show near actual results with convenient computational time; despite highlighting a limitation in APP's adoption of stochastic modelling and metaheuristics approaches. In another notable publication, Kalaf et al. (2021) indicated that highly complex APP problems are difficult to be tackled with mathematical programming techniques and that adopting metaheuristics to solve APP problems is much more successful. They also stated that no single metaheuristic approach could be used to solve all real APP problems and suggested hybrid metaheuristic approaches combining two or more algorithms to improve the solution space search performance.

2.2 Numerical Findings

Through this preliminary study for such a problem, the previously mentioned four search statements related to the three major search tracks helped in illustrating the current status of the search questions mentioned before. The analysis in this sub-section is captured using Scopus Elsevier's abstract and citation database analysis results and will focus on publication type and frequency. Table 4 and Figure 3 show the summary of each search statement. Based on the searches' results, a low number of publications is present across all searches, and with a considerable number of recent publications relative to the total number of publications. The percentage number of publications published in the last 10 years relative to the total number of publications for each search is 30%, 24%, 78%, and 76%, respectively. Such percentages indicate an interest in research in these tracks by scholars across different subject areas. The results also indicate that the terms "Social Sustainability", "Organizational Learning", and "Learning" have been recognized as influencing factors in the APP problem since 1976 and are still under study for further development.

Table 4. Search statements numerical analysis summary

Search Statement		Publication Type	Publication Per Year
1	TITLE-ABS-KEY ("Aggregate Production Planning" OR "Aggregate Planning") AND TITLE-ABS-KEY ("Learning Curve" OR "Learning Rate")	**Total: 10** Articles: 8 Reviews: 1 Conference Papers: 1 **Journal to conference ratio: 8**	Number of publications in last 10 Years: 3 First Document: 1976 Most Recent Document: 2022
2	TITLE-ABS-KEY ("Aggregate Production Planning" OR	**Total: 33** Articles: 25	Number of publications in last 10 Years: 8

	Search Statement	Publication Type	Publication Per Year
	"Aggregate Planning") AND ALL ("Organizational learning" OR "learning rate" OR "learning curve")	Book Chapters: 3 Reviews: 3 Books: 1 Conference Papers: 1 **Journal-to-conference ratio: 25**	First Document: 1976 Most Recent Document: 2022
3	TITLE-ABS-KEY ("Aggregate Production Planning" OR "Aggregate Planning") AND TITLE-ABS-KEY ("Social" OR "Social Sustainability")	**Total: 18** Articles: 11 Reviews: 2 Conference Papers: 5 **Journal-to-conference ratio: 2.2**	Number of publications in last 10 Years: 14 First Document: 1977 Most Recent Document: 2022
4	TITLE-ABS-KEY ("Aggregate Production Planning" OR "Aggregate Planning") AND ALL ("Meta-Heuristic" OR "Metaheuristic")	**Total: 21** Articles: 13 Reviews: 3 Conference Papers: 5 **Journal-to-conference ratio: 2.6**	Number of publications in last 10 Years: 16 First Document: 2007 Most Recent Document: 2021

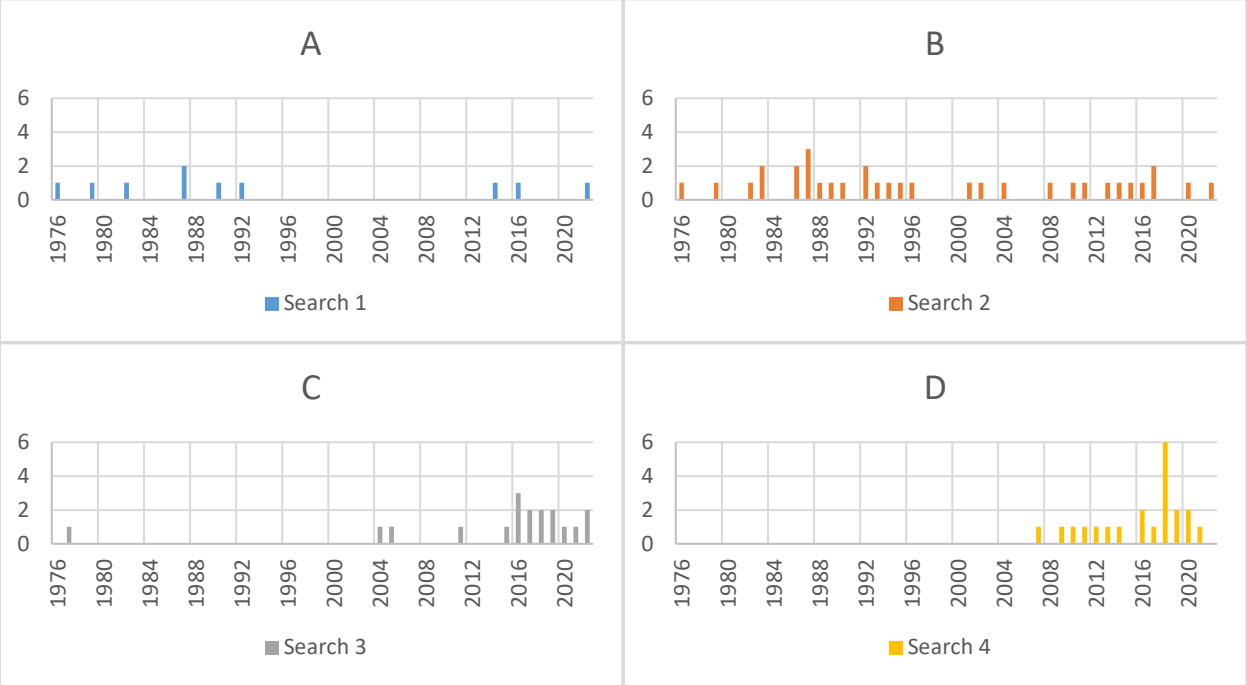

Figure 3. A, B, C, and D charts show distribution of publications over years for search statements 1, 2, 3, and 4 respectively.

3. Summary and Limitations

In summary, this review has analyzed the current state of the incorporation of workforce experience evaluation and social sustainability in Aggregate Production Planning (APP) problem. Also, the solution approaches and modelling techniques used were analyzed. It could be concluded that, while the impact of the learning curve on the APP problem has received some attention in the literature, the consideration of organizational learning with a multi-variable learning curve model is limited. Also, incorporating social sustainability aspects such as workforce health, work-life balance, and other aspects is less common. Metaheuristics have been identified as a promising approach for addressing the

complexity of APP problems, and many different metaheuristics have been applied for similar applications. However, more research is needed to fully understand its potential in solving APP problems, including the use of hybrid approaches.

The incorporation of organizational learning into the APP model can contribute to cost reduction and optimized workforce management, while the consideration of social sustainability measures ensures a proper balance of human resources in production systems. Additionally, the use of metaheuristics ensures higher responsiveness to variable fluctuations in the planning system.

This review has identified several potential future research directions to enhance the APP process. First, there is a need to investigate ways to further enhance the workforce learning effect through employee training, combining individual and organizational learning, and reducing the forgetting effect. Second, more research is needed to understand how organizational learning impacts different types of industries and how it changes over time according to the applied management model. Third, future research should investigate how organizational learning impacts all sustainability pillars throughout production systems and address a set of quantitative and qualitative social sustainability measures for each type of industry. Finally, there is a need to develop solution approaches that consider the uncertainty of variables.

The conducted review has some limitations. Firstly, some articles related to the research field were not accessible to review. Secondly, the consideration of social sustainability in APP is assumed to be based on the common definitions of sustainable manufacturing and production planning as there is no standard definition. Finally, the in-depth analysis of the interrelation between social sustainability and organizational learning was not considered in this study.

References

Abu Bakar, M. R., Bakheet, A. J. K., Kamil, F., Kalaf, B. A., Abbas, I. T., & Soon, L. L. , Enhanced Simulated Annealing for Solving Aggregate Production Planning. *Mathematical Problems in Engineering*, *2016*. https://doi.org/10.1155/2016/1679315

Attia, E. A., Megahed, A., & Duquenne, P., Towards a learning curve for electric motors production under organizational learning via shop floor data. *IFAC-PapersOnLine*, *49*(12), 1086–1091,2016. https://doi.org/10.1016/j.ifacol.2016.07.587

Attia, E.-A., Megahed, A., AlArjani, A., Elbetar, A., & Duquenne, P., Aggregate production planning considering organizational learning with case based analysis. *Ain Shams Engineering Journal*, *13*(2), 101575,2022. https://doi.org/10.1016/j.asej.2021.09.002

Baykasoglu, A., & Gocken, T., Multi-objective aggregate production planning with fuzzy parameters. *Advances in Engineering Software*, *41*(9), 1124–1131,2010. https://doi.org/10.1016/j.advengsoft.2010.07.002

Chakravarty, A. K., Shtub, A., & Freeman, A. B. , THE EFFECT OF LEARNING ON THE OPERATION OF MIXED-MODEL ASSEMBLY LINES*. *Production and Operations Management Society (POMS)*, *I*(2),1992.

Cheraghalikhani, A., Khoshalhan, F., & Mokhtari, H., Aggregate production planning: A literature review and future research directions. *International Journal of Industrial Engineering Computations*, *10*, 309–330,2019. https://doi.org/10.5267/j.ijiec.2018.6.002

Ebert, R. J. (1976). AGGREGATE PLANNING WITH LEARNING CURVE PRODUCTIVITY. *Management Science*, *23*(2), 171–182. https://doi.org/10.1287/mnsc.23.2.171

Gagnon, R. J., & Krasner, J. D. (1990). The Optimal Mix of InternaUExternal Engineering Staff and Equipment With Different Levels of Capability and Performance. In *IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT* (Vol. 37).

Goli, A., Tirkolaee, E. B., Malmir, B., Bian, G. bin, & Sangaiah, A. K. , A multi-objective invasive weed optimization algorithm for robust aggregate production planning under uncertain seasonal demand. *Computing*, *101*(6), 499–529,2019. https://doi.org/10.1007/s00607-018-00692-2

Guzman, E., Andres, B., & Poler, R., Models and algorithms for production planning, scheduling and sequencing problems: A holistic framework and a systematic review. *Journal of Industrial Information Integration*, *27*, 100287, 2022. https://doi.org/10.1016/j.jii.2021.100287

Hahn, G. J., & Brandenburg, M., A sustainable aggregate production planning model for the chemical process industry. *Computers and Operations Research*, *94*, 154–168, 2018. https://doi.org/10.1016/j.cor.2017.12.011

Hossain, M. S., & Islam, K. M., PSO-based harmony search algorithm to aggregate production planning under possibilistic environment. In *Int. J. Services and Operations Management* (Vol. 31, Issue 2),2018.

Jamalnia, A., Yang, J.-B., Feili, A., Xu, D.-L., & Jamali, G. (2019). Aggregate production planning under uncertainty: a comprehensive literature survey and future research directions. *The International Journal of Advanced Manufacturing Technology*, *102*(1–4), 159–181. https://doi.org/10.1007/s00170-018-3151-y

Kalaf, B. A., Mohammed, G. J., & Salman, M. D. , A New Hybrid Meta-Heuristics Algorithms to Solve APP Problems. *Journal of Physics: Conference Series*, *1897*(1), 2021. https://doi.org/10.1088/1742-6596/1897/1/012011

Kaveh, M., & Dalfard, V. M., A simulated annealing algorithm for aggregate production planning with considering of ancillary costs. In *International Journal of Information Technology and Decision Making and etc* (Vol. 6, Issue 4), 2014. Neural Computing and Applications.

Khaled, M. S., Shaban, I. A., Karam, A., Hussain, M., Zahran, I., & Hussein, M., An Analysis of Research Trends in the Sustainability of Production Planning. In *Energies* (Vol. 15, Issue 2). MDPI, 2022. https://doi.org/10.3390/en15020483

Khokhar, M., Iqbal, W., Hou, Y., Abbas, M., & Fatima, A. , Assessing supply chain performance from the perspective of pakistan's manufacturing industry through social sustainability. *Processes*, *8*(9), 2020. https://doi.org/10.3390/pr8091064

Khoshnevis, B. (1979). *AGGREGATE PRODUCTION PLANNING MODELS INCORPORATING DYNAMIC PRODUCTIVITY* [Doctor Of Philosophy Thesis]. Oklahoma State University.

Khoshnevis, B., Wolfe, P. M., & Terrell, M. P., Aggregate planning models incorporating productivity—an overview. *International Journal of Production Research*, *20*(5), 555–564, 1982. https://doi.org/10.1080/00207548208947786

Kim, S. C., & Kim, Y. W., Workforce information database system to support production planning in construction projects. *Journal of Civil Engineering and Management*, *18*(6), 867–878, 2012. https://doi.org/10.3846/13923730.2012.725675

Kumar Badhotiya, G., Soni, G., & Mittal, M. L. (2018). An analysis of mathematical models for multi-site production and distribution planning. In *Int. J. Intelligent Enterprise* (Vol. 5, Issue 4).

Kumar, S. A., & Suresh, N. (2009). *Operations Management*. New Age International. https://books.google.com.eg/books?id=LYtmIR8UwjUC

Levin, N., & Globersont, S. (1993). Generating learning curves for individual products from aggregated data. In *INT. J. PROD. RES* (Vol. 31, Issue 12).

Luangpaiboon, P., & Aungkulanon, P., Hybridization of Metaheuristics for Multi-Objective Aggregate Production Planning with Desirability Function on Food-Beverage Demand. *Advanced Science Letters*, *19*, 3632–3636, 2013. https://doi.org/10.1166/asl.2013.5224

Mehdizadeh, E., Niaki, S. T. A., & Hemati, M., A bi-objective aggregate production planning problem with learning effect and machine deterioration: Modeling and solution. *Computers and Operations Research*, *91*, 21–36, 2018. https://doi.org/10.1016/j.cor.2017.11.001

Mehta, S. J., Soni, G., Jain, V., Kumar Badhotiya, G., & Mittal, M. L. , Multisite aggregate production and distribution planning: a review Satya Prakash. In *Int. J. Enterprise Network Management* (Vol. 9),2018.

Nobari, A., Khierkhah, A., & Hajipour, V., A Pareto-based approach to optimise aggregate production planning problem considering reliable supplier selection. In *International Journal of System Science, Engineering Optimization* (Vol. 29, Issue 1), 2018.

Rasmi, S. A. B., Kazan, C., & Türkay, M., A multi-criteria decision analysis to include environmental, social, and cultural issues in the sustainable aggregate production plans. *Computers and Industrial Engineering*, *132*, 348–360, 2019. https://doi.org/10.1016/j.cie.2019.04.036

Sakallı, Ü. S., Baykoç, Ö. F., & Birgören, B., A possibilistic aggregate production planning model for brass casting industry. *Production Planning & Control*, *21*(3), 319–338, 2010. https://doi.org/10.1080/09537280903449438

Saracoglu, O., Arslan, M. C., & Turkay, M. (2015). Aggregate planning problem from sustainability perspective. *2015 4th International Conference on Advanced Logistics and Transport (ICALT)*, 181–186, 2015. https://doi.org/10.1109/ICAdLT.2015.7136616

Silveira, M. A., Kikuchi, L. S., Policeno, C. A., & Gardim, N., Dynamization of learning for sustainability in the electronics industry: Studies in electromedical equipment manufacturers. *IFAC Proceedings Volumes (IFAC-PapersOnline)*, *6*(PART 1), 532–537, 2013. https://doi.org/10.3182/20130911-3-BR-3021.00076

Türkay, M., Saraçoğlu, Ö., & Arslan, M. C., Sustainability in supply chain management: Aggregate planning from sustainability perspective. In *PLoS ONE* (Vol. 11, Issue 1),2016. Public Library of Science. https://doi.org/10.1371/journal.pone.0147502

Zaidan, A. A., Atiya, B., Abu Bakar, M. R., & Zaidan, B. B., . A new hybrid algorithm of simulated annealing and simplex downhill for solving multiple-objective aggregate production planning on fuzzy environment. *Neural Computing and Applications*, *31*(6), 1823–1834, 2019. https://doi.org/10.1007/s00521-017-3159-5

Zarte, M., Pechmann, A., & Nunes, I. L., Problems, Needs, and Challenges of a Sustainability-Based Production Planning. *Sustainability*, *14*(7), 4092, 2022. https://doi.org/10.3390/su14074092

Biographies

Mostafa Tarek is a M.Sc. student at the Production Engineering Department at Alexandria University. He earned a BSc. degree in Production Engineering from Alexandria University, Egypt, in 2019. His research interests include monitoring real-time operations and applying data science methods to analyze and improve the performance of systems across various industries**.**

Ahmad E. Elhabashy has received his Ph.D. degree in Industrial and Systems Engineering from Virginia Tech, USA, in 2018 and both his B.Sc. and M.Sc. degrees in Production Engineering from Alexandria University, Egypt, in 2009 and 2012, respectively. Ahmad is currently working at the Production Engineering Department at Alexandria University. His research interests include quality control, production planning and control, modelling of industrial systems, and optimization, particularly in manufacturing context.

Hadi Fors is an Assistant Professor of Industrial Engineering at Alexandria University and former Visiting Professor of Industrial Engineering at Arab Academy for Science, Technology, and Maritime Transport. He earned a BSc. degree in Production Engineering from Alexandria University, Egypt and both a MSc degree in Industrial Engineering and a PhD degree in Industrial Engineering from Alexandria University, Egypt. His research interests include modelling and optimization, manufacturing systems, supply chain, and healthcare systems.

M. Hamdy Elwany is Professor of Industrial Engineering at Alexandria University. He is Founder and Member in the Egyptian Operations Research Applications Society, Cairo, Founder Member of Alexandria Operations Research and Scientific Management Society, Member in the Operations Research Society of America [ORSA], Senior Member in the Institute of Industrial Engineering [IIE], USA, Senior Member in The Society of Manufacturing Engineering, and registered professional engineer [PE], USA. Published six books and 100 technical papers and reports in industrial engineering, computer applications, and operations research.