POLITECNICO DI MILANO

PhD in INGEGNERIA GESTIONALE / MANAGEMENT ENGINEERING - 41st cycle

THEMATIC Research Field: AI-DRIVEN AND HUMAN-CENTERED PRODUCTION PLANNING IN INDUSTRY 5.0

Monthly net income of PhDscholarship (max 36 months)
1500.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Production Planning and Control (PPC) has always been a cornerstone of manufacturing systems, ensuring the efficient allocation of resources, synchronization of processes, and timely delivery of products. However, the ongoing transition toward Industry 5.0 is profoundly transforming the role and scope of PPC. While Industry 4.0 focused on automation and digital integration, Industry 5.0 reintroduces the human being at the center of industrial systems, emphasizing collaboration between humans and intelligent machines to achieve sustainable, resilient, and human-centric production.The motivation behind this research stems from the need to rethink traditional PPC frameworks to align with this emerging paradigm. The increasing availability of data and the rapid advances in Artificial Intelligence (AI) and Machine Learning (ML) offer unprecedented opportunities to enhance decision-making in production systems. Yet, their potential remains underexploited when it comes to integrating human knowledge, flexibility, and well-being into planning and control decisions. The main objectives of this PhD project are to: 1. Analyze the evolving role of PPC within the context of Industry 5.0, identifying emerging challenges and opportunities for human machine collaboration; 2. Develop AI- and ML-based decision-support models capable of improving the adaptability, efficiency, and

	responsiveness of production systems while maintaining human oversight and autonomy; 3. Propose a human-centered PPC framework that integrates technological intelligence with human expertise and ethical considerations; 4. Empirically validate the developed framework through simulation environments, assessing its impact on both operational performance and human factors.
Methods and techniques that will be developed and used to carry out the research	The research will adopt a methodological approach that combines simulation modeling and artificial intelligence techniques to explore, develop, and validate innovative frameworks for Production Planning and Control (PPC) in the Industry 5.0 era. A first phase will include a systematic literature review on human-centric and intelligent production systems, identifying how AI and simulation can enhance planning, scheduling, and decision-making while maintaining human oversight. The core of the research will involve the development of Discrete Event Simulation (DES) models to reproduce the dynamics of production systems, allowing the analysis of different human–machine collaboration scenarios. These models will be used to evaluate system performance under varying planning and control strategies, integrating human behavior, learning curves, and decision-making elements. In parallel, Machine Learning (ML) and Artificial Intelligence (AI) algorithms, such as reinforcement learning, neural networks, and predictive analytics, will be developed and trained using synthetic or industrial datasets to optimize PPC decisions (e.g., workload balancing, scheduling, resource allocation). The interaction between simulation and AI will enable data-driven and adaptive decision-making, supporting more resilient and human-centered systems. Finally, the developed models will be validated through industrial case studies and what-if scenario analyses, assessing both operational performance (efficiency, responsiveness) and human-related indicators.

	This integrated approach will provide robust methodological tools to design and manage production systems that are intelligent, flexible, and aligned with the principles of Industry 5.0.
Educational objectives	The research is multidisciplinary in nature: the candidate will develop advanced research skills in the areas of Production Planning and Control, Manufacturing Systems, and AI and ML. She/he will learn how to design and conduct a research project, adopting the proper methodologies for conducting a literature review, data collection and analysis (DES, field experiments), to validate results, and to present and publish results in both academic and practictioner outlets. Such learnings are extremely useful in all the further development of the professional career of the PhD candidate. And introducing people with such a higher level of education in the economic system gives a strong contribution to increase its competitiveness and degree of innovation.
Job opportunities	Because the subject is at the center of the attention of virtually any company, job opportunities are easily available in any manufacturing company. In addition, consulting companies also value the specific competences on the subject, and also the methodologies learned.
Composition of the research group	1 Full Professors 14 Associated Professors 4 Assistant Professors 7 PhD Students
Name of the research directors	Alberto Portioli

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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents	--

Scholarship Increase for a period abroad	
Amount monthly	750.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

The PhD candidate will have access to a comprehensive educational and research environment. They will participate in doctoral-level courses on operations management, sustainable manufacturing systems, data analysis, and qualitative research methods. Educational activities will be complemented by seminars and workshops organized within the School, the research group, and international academic networks.
The research will be carried out in close collaboration with Professor Matthias Thürer, Chair of Factory Planning and Intralogistics at TU Chemnitz, a leading international scholar in the fields of Discrete Event Simulation and Production Planning and Control (PPC). Professor Thürer has been collaborating with the hosting research group for several years on these topics, and his involvement will significantly enhance the scientific quality and international scope of the project.The collaboration will include a research stay abroad of approximately 10 months, divided over the last two years of the PhD program, at TU Chemnitz, providing the candidate with the opportunity to work within an internationally recognized research environment. During the stay in Germany, the candidate will receive an appropriate financial support to cover travels, living and accommodation expenses, ensuring full participation in research activities. This experience will substantially enrich the educational activity and supervision, offering the candidate advanced methodological training and exposure to a world-class research network.
The candidate may also take part in teaching assistantship activities, supporting master's-level courses, thereby strengthening their pedagogical and communication skills.The research group provides two shared offices, where desks are available on a shared basis. In addition, departmental open-space areas can be booked as needed. If required, the candidate may use their allocated research funds to purchase a personal laptop for their research activities.
A regular on-site presence of at least three days per week is required to ensure active collaboration, engagement in research group activities, and integration within the academic environment. Vacation periods generally include three weeks in August and one week during the Christmas holidays, and are agreed upon with the PhD supervisor.

For the overall development of their capabilities, PhD candidates will work on sinergical projects to favour empirical data collection and network development for their career. Projects will give candidates the opportunity to work in groups (peers and other senior professors).

If coherent with the development of their doctoral program, the PhD candidate will have the opportunity to be involved in: teaching activities, tutoring to master students, tutoring to PhD candidates for administrative processes.

Funding for educational activities: 6.100,00 Euros for three years.