



PhD in INGEGNERIA GESTIONALE / MANAGEMENT ENGINEERING - 38th cycle

**PARTENARIATO PNRR Research Field: CLOSED-LOOP PRODUCTION IN CIRCULAR
MANUFACTURING BASED ON DIGITAL TWINS**

Monthly net income of PhDscholarship (max 36 months)

€ 1450.0

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**

This PhD position focuses on the development of operations practices in the setting of Circular Manufacturing strategies, with particular emphasis to the innovation built on one of the most promising Key Enabling Technologies of digitalization - Digital Twins. Considering that i) circular economy and digitalization are amongst the main topics in the "Piano Nazionale di Ripresa e Resilienza (PNRR)"; ii) circular manufacturing needs closed-loop management; iii) digitalization fosters the possibility to operate across different the product lifecycle stages, this action aims at developing high-profile competences in Circular Manufacturing strategies and Key Enabling Technologies, with special attention towards the manufacturing stage of products.

The main objective will be to investigate the nexus between circularity requirements, production activities and systems, and digital technologies, having a special emphasis on Digital Twins. Digital Twins will be particularly studied considering their potential in terms of cognitive capabilities, to enable an integrated decision-making aimed at different impacts both for products and materials and for the production plants. The impacts should consider different aspects such as: production scraps characterization and their reuse in order to extend their resource value; higher raw material efficiency / effectiveness; higher capabilities to recycle production scraps and wastes, or to remanufacture parts and components of both finished products and production



	equipment; high reliability of the production assets and processes.
Methods and techniques that will be developed and used to carry out the research	<p>The following methodologies will be applied in the research project:</p> <ol style="list-style-type: none"> 1) literature analysis to map the situation of the research at national and international level; 2) design and development of closed-loop production management framework, models and architecture, required by Circular Manufacturing strategies, and built on Cognitive Digital Twins as key enabling concept from the technological perspective; 3) conducting field studies in the form of action research on the development of closed-loop production enabled by Digital Twins, especially in high-tech sector; 4) assessing and validating the developed framework, models and architecture through a series of experimental campaigns and experts' judgements.
Educational objectives	<p>Considering the needs from the Extended Partnership 3a_Italy, this scholarship promotes the competence required by digital and green transitions. High-level competence and skills will be developed in order to deal with applications in production contexts considering the requirements from Circular Manufacturing strategies and the potential from Digital Twin implementation as key enabler.</p> <p>On the whole, the research aims to contribute to a high-skill profile that is able to:</p> <ul style="list-style-type: none"> - develop critical thinking capabilities regarding the opportunities and challenges opened by the green and digital transition to competitiveness and circularity of the manufacturing business; - analyze, integrate and contribute to the development of the body of research on Digital Twins and Circularity for industrial engineering; - analyze and evaluate the Digital Twin innovation and the required maturity to support the proficient deployment of closed-loop production practices; - develop models and advanced capabilities to support decision making to enable closed-loop production by means of Digital Twins.



	The project will be carried out within the Extended Partnership "3A-Italy", funded by the PNRR.
Job opportunities	<p>The opportunities for a PhD graduate in this research area are manifold, in terms of professional development in:</p> <ul style="list-style-type: none"> - research and development in the fields of industrial operations, with specific interest for challenges of the twin transitions (digital and green transition); - advisory and consultancy for those companies that want to invest on the next steps of sustainable and smart manufacturing: the PhD graduate will be the right person to lead twin transition projects in manufacturing companies, acting as digital champion, or may be hired by consultancy companies which accompany manufacturing companies in their twin transitions.
Composition of the research group	3 Full Professors 1 Associated Professors 7 Assistant Professors 10 PhD Students
Name of the research directors	Proff. I. Roda, A. Polenghi, M. Macchi

Contacts
irene.roda@polimi.it adalberto.polenghi@polimi.it marco.macchi@polimi.it

Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	725.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
<p>The PhD candidate will have the opportunity to attend courses on Management Engineering research methods and manufacturing research at Politecnico di Milano and other Universities and research centers (e.g. MADE - Competence center Industry 4.0). He/she will be supervised by the research director through meetings and will receive feedbacks on his/her intermediate results</p>



during regular meetings with the Doctorate board and scientific conferences. The candidate will be involved in some teaching and communication activities, which are seen as a major opportunity to practice with dissemination of own and other relevant research results. He/she will be offered a desk and office facilities at the department building.

CUP: D43C22003120001

Decreto Direttoriale Avviso:

D.D. 341 del 15/03/2022 Avviso pubblico per la presentazione di Proposte di intervento per la creazione di Partenariati estesi alle università, ai centri di ricerca, alle aziende per il finanziamento di progetti di ricerca di base nell'ambito del Piano Nazionale di Ripresa e Resilienza, Missione 4 Istruzione e ricerca - Componente 2 Dalla ricerca all'impresa - Investimento 1.3, finanziato dall'Unione europea - NextGenerationEU

Decreto di concessione: D.D. 1551 del 11/10/2022