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BEST4.0

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Deliverable D.1.3.2
SMEs check- up reports: Report on the application of the TML index in the 8 project areas involved

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List of Abbreviations

I4.0	Industry 4.0
SMEs	Small and Medium Enterprises
BEST4.0	Blue Economy Sectors Digital Transformation 4.0
LP	Lead Partner
PP	Partner
WP	Work Package
TML	Technology Maturity Level
DIH	Digital Innovation Hubs
EDIH	European Digitial Innovation Hub
AR	Augmented Reality
VR	Virtual Reality
IoT	Internet of Things
AI	Artificial Intelligence
R&D	Research and Development

1. EXECUTIVE SUMMARY

Objective

This report presents the findings from applying the Technology Maturity Level (TML) Index to small and medium enterprises (SMEs) operating within the Blue Economy across eight cross-border project areas. The TML Index assesses SMEs' capacities and technology readiness levels regarding the nine pillars of Industry 4.0 (I4.0). By providing a TML score, the index serves as a benchmarking tool for tracking SME progress over time, identifying gaps, and guiding digital transformation strategies.

Scope of the Report

- Evaluation of the TML Index in each of the eight project areas.
- Analysis of SMEs' alignment with I4.0 pillars and identification of readiness gaps.
- Comparative insights across project areas and recommendations for future improvements.

2. RESULTS BY PROJECT AREA

Each of the following sections provides an overview of TML Index results for SMEs within each project area, along with specific findings, challenges, and recommendations.

2.1 PROJECT AREA N.1 : LP CNA FERRARA

2.1.1 Overview of SMEs in Blue Economy Sector

According to the report "Ossermare – Osservatorio dell'Econima del Mare 2024", the Emilia-Romagna region plays a significant role in Italy's Blue Economy, contributing 4.6 billion euros in direct added value (2.9% of the regional economy) and supporting over 96,800 jobs. The economic impact is particularly strong in tourism, research, maritime logistics, and shipbuilding.

Key Blue Economy Sectors in Emilia-Romagna are:

1. Tourism and Hospitality (33.9% of the Blue Economy's value)

The region's coastal areas, especially Rimini and Ravenna, are major tourism hubs, generating substantial economic activity from accommodation, food services, and recreational activities.

Rimini ranks among Italy's top five provinces in terms of the Blue Economy's impact on employment (16.2% of total jobs).
Coastal tourism is complemented by water sports and leisure activities, further boosting the region's economic profile.(4,5%)

2. Maritime Research, Regulation, and Environmental Protection (28.1%)
The region invests heavily in marine environmental research, sustainability initiatives, and regulatory frameworks to protect its coastal ecosystems.

3. Shipbuilding and Nautical Industry (16.4%)
Emilia-Romagna has a strong presence in shipbuilding, with Rimini ranking 8th among Italian provinces for export specialization in this sector.
Forlì-Cesena and Rimini are among Italy's top provinces for exports in the nautical industry.

4.Maritime Transport and Logistics (8.3%)
The region plays a key role in cargo and passenger movement, with the Port of Ravenna serving as a strategic hub for goods transportation.

5.Fisheries and Seafood Processing (9.0%)
Emilia-Romagna's fisheries sector contributes significantly to the regional economy, although imports surpass exports in this category.
Rimini ranks among the top 10 provinces in Italy for export specialization in the fishing industry.

Regional Specialties and Strengths:
Rimini: A major tourism and hospitality center, with significant contributions from shipbuilding and fisheries exports.
Ravenna: A crucial maritime logistics hub, supporting goods movement and industrial maritime services.
Forlì-Cesena: A growing center for shipbuilding and marine-related exports.

Overall, Emilia-Romagna's Blue Economy is characterized by strong synergies between tourism, maritime industries, and research, with a high economic multiplier effect that integrates these sectors into the broader regional economy

2.1.2 TML Index Results

The overall TML Index results for SMEs in the Emilia-Romagna region indicate an "Average" level of digital maturity. This suggests that while these organizations have reached a moderate stage in their digital transformation, there is still room for improvement. Blue

Economy SMEs, in particular, could greatly benefit from increased investment in digital technologies and skills to enhance their operations and products.
Currently, digital technology investments support various core business functions, but the level of readiness—reflected in strategic planning and resource allocation—could be strengthened to accommodate more advanced solutions. Employees possess an average level of digital skills; however, achieving greater digital transformation will require well-structured, continuous training. This training should be delivered by specialized IT professionals and through internal knowledge-sharing among more digitally proficient staff members.
While a significant portion of company information is already digitized, implementing a comprehensive data strategy, including robust data security measures, would be highly advantageous. Such an approach would enhance data analysis capabilities and support more informed decision-making. Additionally, adopting digital technologies could help companies improve their sustainability efforts by reducing their environmental footprint and prioritizing eco-friendly digital solutions.
Enhancing digital maturity would not only increase SMEs' competitiveness but also help them close the gap with more digitally advanced competitors in their target markets. Furthermore, it would provide them with a competitive edge over less digitally developed businesses.

Regarding the single dimensions examined, the best performance came out in DIM 3 -Digital Readiness , combined with a quite low perceived level of innovation barriers (DIM5): companies have reached an intermediate stage of digital readiness, effectively integrating major digital technologies across their internal and external operations, including customer and supplier platforms. In serveral cases, digital solutions are connected across all business areas—administration, management, production, marketing, purchasing, logistics, and customer service—ensuring streamlined processes and enhanced efficiency. Where beneficial, companies have begun experimenting with or implementing advanced digital technologies in specific business areas to maximize their potential advantages. This progress provides a distinct competitive edge, bringing companies closer to industry leaders.
Furthermore, when not frightened by the lack of time and money to invest, companies are increasingly engaging with an ecosystem of external stakeholders—such as startups, research centers, lead customers, suppliers, and even competitors—to share costs and risks while accelerating time to market. To reinforce digital transformation efforts, it would be beneficial to strengthen leadership by incorporating representatives from all business areas into the decision-making process. Involving top executives at this level would facilitate the

effective dissemination and implementation of digital initiatives across the entire organization.

2.1.3 Key Challenges

Blue Economy SMEs in Emilia Romagna face challenges such as digital infrastructure gaps, workforce skill shortages, financial constraints, business size limitations, and regulatory pressures, to maintain their interest in digital innovation technologies

1. Limited Access to Digital Infrastructure

While the region is progressing in smart ports and digital maritime logistics, many businesses, particularly SMEs, lack access to high-speed digital infrastructure, IoT-based monitoring systems, and AI-driven analytics.

The uneven adoption of Industry 4.0 solutions in shipbuilding and marine research limits the scalability of innovation.

2. Skills Gaps in the Maritime Workforce

Low levels of digital literacy among traditional maritime workers slow the adoption of advanced technologies such as autonomous vessels, AI-driven logistics, and renewable marine energy solutions.

The region struggles to attract and train specialists in marine robotics, big data analytics, and environmental engineering, which are crucial for advancing TML.

3. Financial Constraints and Investment Challenges

Many businesses, particularly SMEs in shipbuilding, fisheries, and coastal tourism, face high costs when adopting new technologies.

Limited access to venture capital and public funding delays the implementation of cutting-edge solutions, reducing the pace of technological advancement.

Investment in R&D for sustainable maritime solutions is insufficient, slowing progress in areas such as green shipbuilding and offshore renewable energy.

4. Business Size and Competitive Limitations

The small and medium-sized enterprises (SME) dominance in the regional Blue Economy limits economies of scale, making it difficult for firms to invest in high-tech innovations and automation.

Smaller businesses struggle to form international partnerships and R&D collaborations, which are crucial for accelerating TML.

5. Regulatory and Environmental Challenges

Stringent EU environmental regulations require costly technological upgrades for compliance, especially in fisheries, shipping, and marine pollution control.

Climate change-related risks, such as rising sea levels and extreme weather events, require the development of resilient coastal and maritime infrastructure, which is still in the early stages of technological readiness.

2.1.4 Recommendations for Improvement

To accelerate TML growth, Emilia-Romagna needs to expand digital infrastructure, enhance workforce training in emerging maritime technologies, increase financial support for SMEs, and strengthen R&D investments in sustainable Blue Economy solutions. Collaboration between public institutions, universities, and industry players will be critical to overcoming these technological and financial barriers.

To innovate and to improve Emilia-Romagna's Blue Economy competitiveness , a multi-pronged approach is necessary. This includes expanding digital infrastructure, upskilling the workforce, improving financial access, fostering partnerships, and promoting innovation-driven policies.

Some examples:

- To Develop Blue Economy Vocational Programs for new professionals or to upskill senior workers: Integrate digital literacy, cybersecurity, and sustainable maritime tech into regional vocational education.
- To encourage partnerships with major industry players, universities, DIHs, etc., in order to design and manage joint development projects; to exchange good practices and knowledge; to access financing programs; and to do networking
- To use UEFunds or Tax Credit to co-finance expenditure for digital and tech innovation and for the adoption of a sustainable production process.

2.2 PROJECT AREA N. 2 : PP2 CNA ANCONA / MARCHE REGION

2.2.1 Overview of SMEs in Blue Economy Sector

The Marche region in Italy, located along the Adriatic Sea, has a vibrant and diverse Blue Economy, with activities ranging from marine resources to maritime defense. Here's a summary of key Blue Economy sectors and regional specialties for each activity:

1. Marine Living Resources

- Fisheries: The Marche region has a strong tradition in fisheries, especially in coastal towns like Ancona, San Benedetto del Tronto, and Porto Recanati. Local fisheries primarily target anchovies, sardines, mussels, and squid. The region also supports seafood processing industries that contribute to both local and international markets.

- Aquaculture: Sustainable aquaculture practices are growing, with fish farms producing sea bream, sea bass, and mussels. Aquaculture is regulated to prevent overfishing and ensure sustainable harvesting.

2. Marine Non-Living Resources

- Marine Sand and Gravel Extraction: Coastal areas in the Marche region are used for sand and gravel extraction, supporting the construction industry. These resources are harvested from the seabed, though extraction activities are carefully regulated to prevent ecological damage.

3. Marine Renewable Energy

- Offshore Wind Energy: The region has significant potential for offshore wind energy due to favorable wind conditions along its Adriatic coastline. The Marche region is exploring offshore wind farm projects to contribute to Italy's renewable energy goals and reduce dependence on fossil fuels.
- Wave and Tidal Energy: There are emerging efforts to investigate wave and tidal energy potentials along the coast, although this sector is still in its infancy in the region.

4. Post Activities

- Port Services and Logistics: Ports like Ancona, San Benedetto del Tronto, and Porto Recanati are critical for post-shipping activities, including warehousing, distribution, and customs services. These ports handle both cargo and passengers, making the post-activity sector a vital part of the region's economy.

5. Shipbuilding and Repair

- Shipbuilding: Ancona is home to some of Italy's major shipbuilding yards, where commercial vessels, luxury yachts, and ferries are built. The region is well-known for its high-quality maritime construction, especially for the ferry and luxury yacht industries.
- Ship Repair and Maintenance: Alongside shipbuilding, Marche also has a developed sector for ship repair and maintenance. Facilities in Ancona and San Benedetto del Tronto specialize in servicing and maintaining both private and commercial vessels.

6. Maritime Transport

- Ports and Ferries: Ancona Port is a major hub for maritime transport, connecting Italy to various Adriatic countries, including Albania, Croatia, and Greece. The port handles a variety of freight and passenger ferries. Other smaller ports in San Benedetto del Tronto and Porto Recanati support regional transport and logistics.

7. Coastal Tourism

- Tourism Hubs: The Marche region is known for its coastal towns, which serve as tourism hubs. Senigallia, Numana, and Porto Recanati are among the most popular destinations, offering a mix of beach tourism, cultural tourism, and eco-tourism. The

Conero Riviera is famous for its cliffs, beaches, and natural parks, while the Monte Conero region offers opportunities for hiking and marine activities.

- Sailing and Marine Sports: The region is also a center for sailing, with numerous marinas and water sport activities such as kayaking, windsurfing, and diving.

8. Blue Biotechnology

- Marine Biotechnology: The Marche region is exploring marine biotechnology through research into marine organisms and their potential applications in pharmaceuticals, cosmetics, and food industries. The region's universities and research institutions, such as the University of Ancona, are key players in this field, studying bioactive compounds from marine life for medical and industrial applications.

9. Maritime Defense

- Naval Facilities: The Marche region plays a role in maritime defense, with the Port of Ancona serving as a strategic point for the Italian Navy and coast guard operations. The region's maritime security is supported by surveillance systems, patrol vessels, and collaborations with national defense agencies to protect its coastal and maritime interests.

10. Research and Infrastructure

- Marine Research: The Marche region is home to a number of research institutions focused on marine science, including the National Institute of Oceanography and Applied Geophysics (OGS), which conducts research on marine environments, climate change, and oceanic resources.
- Infrastructure Development: The region has a strong focus on infrastructure development to support the Blue Economy, including investments in port facilities, marinas, and offshore energy installations. The development of smart ports and logistics centers in Ancona is a key priority for regional economic growth.

Main blue economy sectors of regional SMEs:

- Production, processing and distribution of fish products;
- Cargo and warehousing, port services;
- Shipbuilding, equipment and machinery;
- Passenger transport, freight transport, services for transport;
- Accomodation, transport for tourits.

2.2.2 TML Index Results

The average TML Index result for Blue Economy SMEs in Italy's Marche Region indicates a medium level of digital maturity. While there are notable strengths, there is still significant room for improvement in digital transformation.

Currently, these SMEs benefit from digital investments supporting core business operations, and a substantial portion of their information is already digitized. Staff possess average digital skills, and there is a growing awareness of the importance of sustainability in operations. These factors provide a solid foundation for further progress, with the potential to secure a competitive advantage over less digitally developed competitors.

However, limitations remain. Investments in digital technologies are narrow in scope, focusing primarily on administrative functions rather than strategic areas such as artificial intelligence, e-commerce, or automation. Planning and resource allocation for advanced solutions are inadequate, leaving the organization underprepared for more sophisticated digital transformations.

Additionally, while staff have a basic level of digital proficiency, structured and continuous training is lacking. There is a clear need for programs led by specialized IT professionals and internal experts to develop skills further. Despite the digitization of information, the absence of a comprehensive data strategy—covering data analysis, security, and decision-making—prevents the organization from maximizing its potential. Moreover, sustainability efforts need to be reinforced by adopting environmentally friendly technologies and prioritizing eco-conscious digital products.

To address these challenges, SMEs should expand digital investments into advanced technologies, develop a clear digital transformation strategy, and implement consistent workforce training programs. Establishing a comprehensive data strategy will enhance decision-making and operational efficiency, while integrating sustainability into digital initiatives will align operations with global ecological standards.

By taking these steps, Blue Economy SMEs in the Marche Region can enhance their digital maturity, strengthen their competitive position, and achieve long-term growth in a rapidly evolving market.

2.2.3 Key Challenges

SMEs in the **blue economy sector** in the **Marche region** face several specific challenges that could impact their **TML** scores. These challenges may limit their ability to fully integrate and leverage advanced technologies, which are critical for growth and sustainability in this sector. Some of the main challenges include:

1. Limited Access to Digital Infrastructure

- Connectivity Issues: Despite the effort of enhancing internet connectivity many SMEs in the Marche region may still face issues with reliable and high-speed internet access. This limits their ability to adopt digital tools essential for innovation, data collection, and management, especially for sectors like maritime, fisheries, and marine tourism.
- Digital Transformation Barriers: Without robust digital infrastructure, SMEs struggle to implement advanced technologies like IoT (Internet of Things) for monitoring marine environments or AI-based systems for efficient resource management.
- Limited Availability of Digital Platforms: SMEs may lack access to tailored platforms or online marketplaces for blue economy products and services, hindering their competitiveness and global reach.

2. Skills Gaps and Talent Shortages

- Lack of Digital and Technological Skills: SMEs in this sector often face difficulties in finding employees with the required technical expertise in areas such as marine technology, data analytics, digital marketing, and sustainable practices. This creates a barrier to technological adoption and hampers innovation.

3. Financial Constraints

- Limited Access to Funding: Many SMEs in the Marche region may struggle with accessing the financial resources needed to adopt and implement new technologies. Traditional financing options may not be suitable for small businesses in niche sectors like the blue economy. Furthermore, high capital investment requirements for sustainable technologies or green innovations could be a barrier.
- Risk Aversion and Investment Hesitancy: Many small businesses in the blue economy sector may be hesitant to invest in new technologies due to perceived risks or lack of immediate returns. This can slow the adoption of digital solutions, ultimately affecting their TML scores and their competitiveness.
- Inadequate Support for Innovation: While there are EU funding programs and national initiatives to support technological innovation, SMEs may face challenges in navigating complex application processes or may lack the knowledge to access the right financial support, such as grants for green technology or digital infrastructure development.

4. Regulatory and Bureaucratic Challenges

- Complex Regulations: The blue economy sector is often subject to stringent environmental and maritime regulations. SMEs in the Marche region may struggle to comply with complex rules, especially when adopting new technologies that require regulatory approval or certification.

- Slow Adoption of Sustainable Practices: Regulatory delays or unclear guidelines around sustainable practices, such as reducing carbon emissions or meeting eco-certification standards, may discourage SMEs from adopting green technologies or transitioning to sustainable operations.

5. Environmental and Climatic Challenges

- Climate Change and Environmental Uncertainty: The blue economy sector in Marche is closely tied to the marine and coastal environment. SMEs face challenges in responding to changing weather patterns, sea-level rise, and the preservation of marine biodiversity. This can affect their operations and the feasibility of adopting certain technologies, especially those that rely on stable environmental conditions.
- Natural Resource Scarcity: Overfishing, habitat destruction, or coastal pollution can impact the availability of resources critical for blue economy activities, affecting the sustainability of SMEs in the sector.

6. Collaborative Barriers and Networking

- Lack of Cross-Sector Collaboration: Collaboration between SMEs, research institutions, government bodies, and larger corporations may be lacking, which could limit access to knowledge, expertise, and technological innovations. Networking opportunities for small enterprises in the blue economy sector may be insufficient, further limiting their ability to raise TML scores.
- Fragmentation of the Sector: The blue economy in Marche could be fragmented, with many small players working independently. This lack of a cohesive industry structure can prevent shared learning and collective action toward technology adoption.

Conclusion

The SMEs in the Marche region face several hurdles in accessing digital infrastructure, overcoming skill gaps, and securing the financial resources necessary to improve their Technology Maturity Levels (TMLs). These challenges hinder their ability to implement advanced technologies, adapt to environmental changes, and remain competitive in the blue economy. Addressing these challenges will require coordinated efforts to improve digital infrastructure, provide training, offer targeted financial support, and foster collaboration across the sector

2.2.4 Recommendations for Improvement

To enhance the Technology Maturity Level (TML) scores of SMEs in the blue economy sector in the Marche region, it is essential to address the challenges related to digital infrastructure, skills gaps, financial constraints, and regulatory barriers. Below are some targeted

recommendations that could help improve the adoption of advanced technologies, increase innovation, and foster sustainable growth in this sector:

1. Strengthening Digital Infrastructure

- Improve Connectivity: The region could benefit from initiatives to improve broadband access, especially in coastal and rural areas where many SMEs are located. Public-private partnerships could help bring high-speed internet infrastructure to underserved regions.
- Provide Digital Platforms and Tools: Develop or promote access to digital platforms and software tailored to the blue economy. This includes cloud-based solutions for marine data analysis, e-commerce platforms for local seafood or tourism businesses, and digital tools for managing marine resources.

2. Addressing the Skills Gap

- Collaborative Training Programs: Establish industry-specific training programs that focus on digital literacy, technology adoption (e.g., IoT, AI), and sustainable practices. These could be developed in collaboration with universities, research institutions, and trade associations.
- Digital Literacy and Innovation Skills: Launch short-term and specialized training courses for SMEs' employees, aimed at bridging the digital skills gap. Focus on key areas such as data analytics, artificial intelligence, renewable marine energy, and environmental monitoring technologies.
- Internship and Apprenticeship Programs: Create opportunities for students or young professionals to gain hands-on experience in SMEs within the blue economy sector, allowing them to build practical skills and helping businesses address their workforce gaps.

3. Accessing Financial Support

- EU and National Grants and Subsidies: SMEs in the blue economy should be encouraged to apply for EU funds, such as the European Maritime and Fisheries Fund (EMFF) or Horizon Europe programs, which support sustainability and innovation in the maritime sector. Additionally, national grants focusing on digitalization and environmental sustainability should be promoted.
- Green Finance and Impact Investment: Establish incentives for green financing, such as low-interest loans or equity investments, to support the adoption of sustainable technologies like renewable marine energy, waste management systems, and eco-friendly products.
- Venture Capital and Angel Investors: Foster connections between blue economy SMEs and investors interested in supporting innovative, sustainable, and scalable businesses in the maritime and coastal sectors.

4. Promoting Innovation and Collaboration

- Research and Development (R&D) Partnerships: Encourage SMEs to partner with research institutions and universities to develop new products, services, and technologies. This could include joint R&D projects focusing on marine conservation, sustainable fisheries, or renewable energy technologies.
- Collaborative Innovation Networks: Create regional innovation hubs or networks that allow SMEs to collaborate on projects, share best practices, and access shared resources like testing facilities and market research. These networks could be focused on specific sectors within the blue economy, such as marine tourism, sustainable fisheries, or marine energy.

5. Navigating Regulatory Challenges

- Streamline Regulatory Processes: Simplify the regulatory processes around adopting new technologies and environmentally sustainable practices. For instance, provide SMEs with clearer guidelines on how to comply with EU and national environmental regulations.
- Incentivize Sustainable Practices: Offer financial incentives for SMEs that adopt sustainable technologies (e.g., renewable energy for boats, eco-friendly packaging for seafood products). This can help alleviate the upfront costs associated with adopting new technologies.

6. Building Awareness and Market Demand

- Consumer Education Campaigns: Launch awareness campaigns targeting consumers to emphasize the importance of supporting sustainable businesses in the blue economy. Educating the public on the benefits of sustainable seafood, eco-tourism, and green technologies can drive demand for these products and services.
- Boosting Internationalization: Help SMEs access international markets by providing resources and advice on exporting blue economy products and services. Promote regional initiatives that align with global sustainability goals.

By addressing these challenges, SMEs in the blue economy sector in the Marche region can enhance their TML scores and increase their competitiveness. The key to success lies in a holistic approach that combines access to digital infrastructure, targeted training, financial support, and collaborative partnerships, while also addressing regulatory barriers. With a focus on innovation, sustainability, and market demand, these SMEs can play a significant role in the growing blue economy and contribute to the region's sustainable development.

2.3 PROJECT AREA N.3 : PP3 CETMA

2.3.1 Overview of SMEs in Blue Economy Sector

With approximately 800 kilometers of coastline, Puglia is one of the Italian regions with the longest coast, second only to regions like Liguria and Sicily. The ports of Puglia, particularly Bari and Brindisi, are among the most active in Italy, both for passenger and freight traffic. Brindisi, for example, is an important connection point with Greece and the Balkans. Puglia is a highly appreciated tourist destination, thanks to its beaches, cultural heritage, and gastronomic traditions. This has led to an increase in maritime traffic, especially in tourist ports. Puglia has also invested in promoting the Blue Economy, aiming to sustainably utilize marine resources, positioning itself as an example of sustainable development within the national context. In addition to its main ports, Puglia has a network of smaller ports and landings that support economic activity and tourism, contributing to economic diversification.

In summary, Puglia plays a significant role in the Italian maritime landscape, both for its coastline length and the importance of its ports in commercial and tourist traffic. Main covered sector of the Blue Economy are represented by:

Maritime Technologies: This sector includes shipbuilding, boat manufacturing, and marine engineering, with SMEs engaged in developing lightweight materials, high-performance vessels, and energy-efficient maritime technologies. The integration of Industry 4.0 solutions, such as IoT-based monitoring systems and digital twin simulations, is gradually enhancing production efficiency and operational performance.

Marine Renewable Energy: The region is at the forefront of marine-based energy solutions, with SMEs focusing on floating solar panels, hydrogen production, and sustainable desalination technologies. These companies leverage AI and big data analytics to optimize energy generation and resource utilization, with ongoing pilot projects demonstrating the feasibility of large-scale deployment.

Fisheries and Aquaculture: Traditional sectors like fisheries and aquaculture are undergoing a digital transformation, with the adoption of IoT-based tracking systems, predictive analytics for fish stock management, and automation in seafood processing. Sustainable practices, such as circular economy approaches and waste reduction strategies, are becoming central to improving industry resilience and market competitiveness.

Tourism and Cultural Heritage: Puglia's coastal tourism is enriched by cultural institutions, historical preservation initiatives, and marine ecotourism development. SMEs in this sector

are integrating augmented reality experiences, digital visitor engagement platforms, and AI-driven cultural content management to enhance accessibility and outreach.
Port Activities and Logistics: As a strategic hub in the Mediterranean, Puglia's ports are modernizing through cloud computing, cybersecurity enhancements, and real-time tracking systems. The adoption of AI-driven logistics and automation in cargo handling is improving efficiency, while digital transformation efforts aim to optimize supply chain transparency and environmental sustainability.
Collectively, these sectors contribute to Puglia's sustainable development and align with broader national and international Blue Growth strategies.

2.3.2 TML Index Results

Taking into account previous specification, CETMA drafted a first list of small and medium enterprises that could cover more than one sector. Most of the companies reached, works on energy harvesting, ship building, sport equipment and tourism, so Energy and Environment and Advanced Manufacturing are thematic most covered. We would also highlight that most of the company have highly innovative processes or product since they are small Start-up related to the Blue Economy sector.

To get direct contacts and to perform all interviews, CETMA use the following database:

- List of CETMA's customers and direct contacts since our born in 1994;
- List of Enterprises that are part of the CONSORZIO NAUTICO PUGLIA (Puglia Nautical Consortium);
- Direct collaboration and list of Start-up accelerated by FAROS the Accelerator Blue Economy from the national network CDP;
- List of exhibitor that participate into the SNIM - Salone Nautico di Puglia that took place in Brindisi in October.

The overall TML Index results for the interviewed SMEs in Puglia's Blue Economy indicate a varied level of digital maturity, with certain industries demonstrating advanced technological integration, while others face barriers to adoption. The overall TML Index is from Basic to Average, but should be also noticed that most of the company are small Start-up with low level of I4.0 technologies integrations.
An in-depth analysis of all assessment dimensions in Apulia reveals significant disparities in the levels of technological and digital maturity across SMEs. Readiness for Innovation and Anthropocentric Digitization exhibit the lowest scores, indicating that most businesses face substantial challenges in fostering a structured approach to innovation and integrating

digital tools that enhance workforce capabilities. This suggests a limited investment in research and development activities, as well as a lack of digital training programs aimed at improving employee engagement with advanced technologies.

Conversely, the Business Technology Strategy dimension demonstrates relatively higher scores, reflecting a more structured approach to technology adoption in certain sectors. Many SMEs have started implementing digital tools within their business operations, particularly in areas such as process optimization and supply chain management. However, the ability to leverage these technologies strategically and to scale digital initiatives remains inconsistent across industries.

Innovation Barriers remain notably high, underscoring the persistent challenges that hinder SMEs from adopting disruptive technologies. These include financial constraints, insufficient knowledge of Industry 4.0 solutions, and limited collaboration between businesses and research institutions. Despite these obstacles, Digital Readiness across SMEs shows an average level of adoption, suggesting that while companies acknowledge the importance of digital transformation, their ability to implement advanced solutions varies widely. Many businesses are at an intermediate stage of digitalization, relying on basic digital tools but struggling to integrate more sophisticated systems such as artificial intelligence, augmented reality, or big data analytics.

Overall, the results highlight the need for targeted support measures, including financial incentives, training programs, and strategic partnerships, to facilitate a more comprehensive digital transformation across the Blue Economy sectors in Apulia.

Key findings include:

- Higher Adoption: SMEs in marine renewable energy and shipbuilding show greater engagement with digital twin technology, IoT-based monitoring, and cloud-based data management. Companies that promote new technologies or new products are generally more prepared into the adoption of new technologies.
- Lower Adoption: Sectors like fisheries and tourism demonstrate lower levels of digital transformation, with limited access to automated tracking, big data analytics, and AI-enhanced operations.

Challenges to digital maturity include financial constraints, knowledge gaps, and difficulty in integrating digital tools into traditional workflows. Although there is a strong awareness of the importance of Industry 4.0 solutions, SMEs require structured support to implement them effectively.

2.3.3 Key Challenge

Several challenges hinder SMEs in Puglia from achieving optimal Technological Maturity Levels (TML):

- **Limited Company Size:** Many SMEs operate with small teams and constrained resources, making it difficult to establish dedicated R&D initiatives.
- **Skills and Knowledge Gaps**: A lack of digitally trained personnel reduces the capacity to leverage AI, cybersecurity, and big data tools.
- **Financial Constraints**: Limited funding opportunities slow the adoption of automated production, AI-enhanced analytics, and real-time monitoring systems.
- **Regulatory and Infrastructure Barriers:** Sectors such as renewable energy and fisheries face complex regulatory landscapes that can delay technological implementation.
- **Fragmented Collaboration:** Weak networks between SMEs, research institutions, and technology providers hinder knowledge-sharing and innovation diffusion.

2.3.4 Recommendations for Improvement

To enhance the technological and digital maturity of SMEs in Puglia's Blue Economy, targeted support services and initiatives are recommended:

- **Advisory Services:** Provide guidance on digital innovation, intellectual property, and industry megatrends to help SMEs formulate structured digital strategies.
- **Strategic Partnerships:** Facilitate collaborations between SMEs and technology providers, enabling the adoption of AI-driven automation, cybersecurity frameworks, and predictive analytics tools.
- **Pilot Demonstrations:** Implement regional demonstration projects focused on digital transformation in shipbuilding, renewable energy, fisheries, and tourism, offering hands-on experience with Industry 4.0 solutions.
- **Capacity Building:** Organize training programs, workshops, and networking events to strengthen digital skills, cybersecurity awareness, and AI implementation capabilities.
- **Access to Funding:** Assist SMEs in securing regional, national, and EU funding for digitalization projects, ensuring financial support for automation, AI, and cloud computing adoption.

By integrating Industry 4.0 technologies and sustainability principles, SMEs in Puglia can enhance their competitiveness, improve operational efficiency, and align with the global shift towards digital and ecological transformation.

2.4 PROJECT AREA N.4 : PP4 AREA

2.4.1 Overview of SMEs in Blue Economy Sector

In the Italian economic panorama, the Blue economy sector continues to demonstrate excellent vitality. This is what emerges unanimously from numerous reports and studies. The **"XII Report on the Economy of the Sea"** (2024) by the Tagliacarne Study Center highlights that in 2022 the sector generated over 64 billion euros in added value, employing more than a million people. This development has contributed to increasing the weight of the blue economy on the national GDP from 3.4% to 3.7%. Among the main drivers of growth are maritime transport (+19.0%) and shipbuilding (+11.9%).

The extra gear of the Blue economy in Friuli Venezia Giulia is also confirmed by other surveys and reports, among which it is worth mentioning the survey of the Chamber of Commerce of Udine and Pordenone **"Economy of the sea in Friuli Venezia Giulia"** (2024) from which it is clear how much it contributes to the formation of added value, with a total of 2.7 billion euros, equal to 7.2% of the overall added value of the region against an Italian average of 3.7%. This means that in the national ranking for the incidence of the added value of the value of the sea economy on the total value of the economy, Friuli Venezia Giulia is the second Italian region after Liguria. The high incidence recorded in FVG derives almost entirely from the contribution of Trieste which, in the provincial ranking for the incidence of the added value of the Blue economy on the total added value of the local economy, stands out in 1st place with 18.9%.

These data are also reflected in the number of employed people and businesses. Employed people in Friuli Venezia Giulia account for 5.2% of the total regional employed people, against a national average of 4.1% (8th place in Italy), while the companies of the Maritime Economy are equal to 4.1% of the regional companies, against an Italian average of 3.8%. The growth in employment and in the number of companies is fueled by a supply chain that includes shipbuilding, transport and logistics, as well as emerging sectors such as environmental protection. This dynamic, which finds an important outlet in exports (with Trieste among the leading provinces for shipbuilding exports), strengthens the international appeal of the region and its competitive positioning in the Mediterranean.

The very recent report of the Maritime technology cluster MareFvg **"Innovation, sustainability and skills"** (2024) confirms data and trends described above, also highlights a notable propensity for innovation of a good part (43%) of the 1,350 companies of the Blue Economy supply chain, 67.9% of which have active good practices in terms of sustainable development, focused on employees who represent a strategic priority.

The report also highlights the challenges and opportunities facing the sector, highlighting a significant gap in internal sustainability leadership, with three-quarters of firms lacking a dedicated role. However, the industry's strong financial health and growing investments in green innovation present opportunities for further advancement.
In Friuli Venezia Giulia, the Blue Economy encompasses a variety of sectors that leverage marine and maritime resources for economic growth, technological advancement, and environmental sustainability. Key sectors include:

- **Maritime Technologies:** this sector covers shipbuilding, boatbuilding, offshore activities, transportation, infrastructure, logistics, and services related to navigation and yachting. The Maritime Technology Cluster FVG, associated partner of Area Science Park in BEST 4.0 project, plays a pivotal role in promoting research, innovation, and training within these domains.
- **Marine Energy**: initiatives like the Interreg Italy-Croatia BEYOND project focus on harnessing offshore wind energy. The project aims to establish a knowledge base that showcases the natural, technical, and legislative environment for the use of offshore wind energy in the Adriatic Sea, promoting sustainable energy solutions in the region.
- **Fisheries and Aquaculture:** these traditional sectors are integral to the region's economy, with ongoing efforts to raise awareness about their potential and promote sustainable practices.
- **Research and Education:** the region emphasizes developing skills and knowledge related to the Blue Economy. Initiatives such as the Summer School in Sustainable Blue Economy in the Euro-Mediterranean Region, in collaboration with SiS FVG institutions, aim to educate and train individuals in sustainable practices. In this context we must not forget that the first Italian marine protected area was established in the territory in 1986, with the mission of protecting and preserving the integrity of the protected area; supporting scientific research applied to the management of marine resources and promoting knowledge of the protected environment.

These sectors collectively contribute to the sustainable development and economic growth of Friuli Venezia Giulia, aligning with broader regional and international Blue Growth strategies.

2.4.2 TML Index Results

The average TML Index result for Blue Economy SMEs in Italy's Friuli Venezia Giulia region indicates a medium level of digital maturity, but there are real heterogeneous cases: some companies, especially the IT providers analyzed, demonstrated notable strengths, while companies that could apply technologies demonstrated gaps and technical needs.

Currently, SMEs recognize the necessity to digitalize processes, products and services but often, due to limited dimensions, they don't have a dedicated R&D staff and limited skills on digitalization and Industry 4.0. The main innovation barriers are time and costs to adopt new technologies, but it's clear the potential to secure a competitive advantage over less digitally developed competitors.
Innovation is incremental and not balanced between incremental and disruptive and even if the companies are collecting a large number of data they do not know how to manage them in a strategic way.
Establishing a comprehensive data strategy will enhance decision-making and operational efficiency, while integrating sustainability into digital initiatives will align operations with global ecological standards.
By taking these steps, Blue Economy SMEs in the Friuli Venezia Giulia Region can enhance their digital maturity, strengthen their competitive position, and achieve long-term growth in a rapidly evolving market.
Overall, the companies of the sample analyzed achieved a TML of 34%, which, as expected, is in the average range according to the model used for the interviews.
The analysis of the 5 dimensions shows the following results:

- **Readiness for innovation**: the average score of the sample is 28.5%, which is in the median range for companies. Most of them own a few patents, although they are engaged in R&D activities which are almost always funded by research projects.
- **Business technology strategy**: the sample shows very heterogeneous results: the average score is 20.2%, that means a "BASIC" level. Most structured companies have defined an investment strategy for digitalization but micro companies not always can do it.
- **Digital readiness:** the average score of the sample is 37.14%; it is aligned with the average for companies with a relatively high level of use of certain technologies.
- **Anthropocentric digitization**: the average score of the sample is 32%. There is a strong emphasis on 'on-the-job' training, with most companies reporting they have highly trained staff with specialized skills.
- **Innovation barriers**: the average score of the sample is 51.22%, which places the companies in the "Moderately advanced" category. In addition to the costs and time required, the problems identified include the "lack of innovation culture" among certain players and the requirements concerning regulation and certification in some European countries.

We noticed that technologies related to simulation and optimization such as digital *twin, cybersecurity and IoT* were the most used among the nine reference technologies.

We found otherwise that technologies like *Big Data, Cloud and Fog Computing and Virtual, Augmented or Mixed Reality* have only a marginal utilization, mainly related to specific needs.

2.4.3 Key Challenges

In Friuli Venezia Region several challenges prevent SMEs from achieving optimal Technological Maturity Levels (TML).
These challenges, as reflected in the TML index results and regional analysis, include:

- **Limited dimension of companies:** there is no specific R&D departments and budget allocated;
- **Skills and Knowledge Gaps**: A shortage of digitally skilled workers, especially in traditional sectors, limits the ability of SMEs to leverage advanced tools and processes effectively;
- **Time and cost barriers**: companies struggle to plan a proper innovation plan and budget to introduce digitalization in their investments;
- **Limited Collaboration**: Weak connections between SMEs and research institutions or IT companies limit the development of digitalization.

2.4.4 Recommendations for Improvement

To enhance the technological and digital maturity of the targeted companies, it would be useful to present a list of support services such as:

- advisory services on: innovation, digital technology, IP, megatrends;
- partnership services: meetings with IT providers, demonstration at EDIH and technology matching with industrial partners and providers; company visits and brokerage events;
- capacity building events: workshops, webinars; local events;
- access to finance: support in funded projects (regional, national, EU funds) and contacts with potential investors.

Sustainability is a topic that most of the SMEs are preparing to adopt in the mid term strategy; it is suggested to insert digital sustainability in the technical skills to improve.

2.5 PROJECT AREA N.5 : PP5 CCE

2.5.1 Overview of SMEs in Blue Economy Sector

Split-Dalmatia County, located along Croatia's Adriatic coast, is renowned for its cultural heritage, scenic landscapes, and vibrant tourism industry. The region is also a key player in maritime activities, shipbuilding, fisheries, and agriculture. With its Mediterranean climate and diverse coastline, the county is ideally situated to implement Blue Economy principles, which aim to foster sustainable use of marine and coastal resources alongside economic growth.

Shipbuilding remains a traditional and, especially in the small shipbuilding sector vital sector in the region, contributing to the Blue Economy through the development of sustainable vessels, environmentally friendly technologies, and energy-efficient ships. Innovations in shipbuilding, such as the use of renewable materials, emission-reducing technologies, and "green" solutions, not only minimize environmental impacts but also enhance the competitiveness of shipyards in the global market.

Fisheries and aquaculture have a long-standing tradition in the county but face sustainability challenges. By adopting innovative practices in sustainable fisheries management and aquaculture, the economic value of these sectors can be improved, while minimizing their environmental impact and ensuring the preservation of marine ecosystems.

Tourism is another key sector, whose further growth and development should be through the implementation of sustainable models that prioritize environmental responsibility, the preservation of natural and cultural-historical resources, and coexistence with the local community.

Sustainable tourism practices can increase the region's long-term competitiveness, while fostering respect for the local culture and environment, and supporting the overall economic development of the county.

Maritime transport and port activities are key components of the Blue Economy, playing an essential role in regional trade and tourism. By adopting sustainable shipping practices, improving port infrastructure, and integrating digital technologies in port management, the efficiency of these sectors can be enhanced, reducing their environmental footprint.

The presence of **IT and development companies** in the region is also a strong asset, driving technological innovation and the modernization of various Blue Economy sectors. Digital transformation can optimize operations in maritime transport, shipbuilding, fisheries, fish processing industry, tourism and other sectors while supporting the development of sustainable energy solutions.

Further potential lies in the use of renewable energy sources such as wave and solar energy, which could contribute significantly to energy sustainability and the reduction of greenhouse gas emissions in the region.
For the continued success of the Blue Economy in Split-Dalmatia County, investment in infrastructure, education, research, and alignment with European environmental standards is essential. With its diverse sectors, including shipbuilding, maritime transport, port activities, IT and development, fisheries, fish processing and preserving industry, aquaculture, tourism the Blue Economy has the potential to become a central driver of sustainable development in the county, balancing economic growth with the preservation of marine and coastal resources.

2.5.2 TML Index Results

The Technology Maturity Level (TML) Index results for SMEs in the project area Split-Dalmatia County indicate a **"Moderate Advanced"** level of technological maturity on average. This reflects some progress in adopting Industry 4.0 principles, but substantial gaps remain in several dimensions.

Results by Dimension are:

1. **Dimension 1: Innovation Readiness**

Score: Moderate readiness for innovation, with strengths in adopting new practices and exploring technology-driven improvements.
Key Insight: SMEs in the IT and research sectors perform well, while fisheries and tourism need support to enhance their readiness.

2. **Dimension 2: Business Technology Strategy**

Score: Moderate but uneven. Some SMEs demonstrate clear strategies for technology integration, while others lack formal plans.
Key Insight: IT and research companies lead in structured technology adoption, but traditional sectors like fisheries struggle to align strategies with I4.0 principles.

3. **Dimension 3: Digital Readiness**

Score: Low scores highlight limited digital integration in traditional sectors.
Key Insight: Advanced tools are utilized by IT firms, while tourism and fisheries lag significantly, particularly in leveraging data-driven technologies.

4. **Dimension 4: Anthropocentric Digitization**

Score: Insufficient workforce skills and limited staff autonomy in engaging with digital technologies.
Key Insight: Significant efforts are needed to upskill employees in traditional industries, particularly in the adoption of user-friendly technologies that enhance productivity.

5. **Dimension 5: Innovation Barriers**

Score: High barriers related to limited funding, digital infrastructure, and organizational resistance to change.

Key Insight: Financial constraints and cultural resistance are major challenges across all sectors.

Cross-cutting I4.0 Pillars)

Score: Average scores indicate basic to moderate implementation of cross-cutting I4.0 concepts, such as automation, connectivity, and data analytics.

Key Insight: Areas like advanced automation and IoT integration remain underdeveloped in most SMEs.

Strengths and Weaknesses

- **Strengths**:

- IT and research companies exhibit strong capabilities in innovation readiness and business technology strategy.
- Certain SMEs have made strides in digital integration, particularly in leveraging basic tools for operational efficiency.

- **Weaknesses**:

- Digital readiness and workforce training are key weaknesses in tourism and fisheries.
- High barriers to innovation, such as inadequate funding and infrastructure, restrict broader technological maturity.
- Low scores in automation and IoT adoption indicate a need for targeted support in advanced I4.0 technologies.

2.5.3 Key Challenges

Despite the significant potential of the Blue Economy in Split-Dalmatia County, several challenges prevent SMEs from achieving optimal Technological Maturity Levels (TML).

These challenges, as reflected in the TML index results and regional analysis, include:

· **Limited Access to Funding**: SMEs, particularly in traditional sectors such as fisheries and tourism, struggle to secure financing for innovation and technological upgrades. This financial limitation is a significant barrier to adopting Industry 4.0 technologies.

· **Fragmented Infrastructure**: Inconsistent digital infrastructure in rural areas hampers the ability of SMEs to integrate advanced technologies, while transportation infrastructure in the region requires further optimization to support economic growth.

· **Skills and Knowledge Gaps**: A shortage of digitally skilled workers, especially in traditional sectors, limits the ability of SMEs to leverage advanced tools and processes effectively.
- **Limited Collaboration**: Weak connections between SMEs and research institutions or IT companies hinder the transfer of knowledge and implementation of innovative solutions.

2.5.4 Recommendations for Improvement

To address the challenges facing the development of the Blue Economy and the technological maturity of SMEs in Split-Dalmatia County, the following recommendations for Improvment are proposed:

1. **Access to Funding:** Facilitate SME access to EU grants and regional financial support mechanisms to fund technological upgrades and innovation.
2. **Awareness Campaigns:** Conduct awareness initiatives to educate SMEs about the benefits of digital transformation and available funding opportunities.
3. **Digital Infrastructure Development:** Invest in improving internet connectivity, particularly in rural and coastal areas, to enable access to digital tools and platforms.
4. **Innovation Hubs and Partnerships:** Establish regional innovation hubs that foster collaboration between SMEs, academic institutions, and technology providers.
5. **Regulatory Support:** Simplify compliance processes and provide SMEs with guidance on navigating environmental and maritime regulations.
6. **Sustainability Initiatives:** Promote the adoption of renewable energy solutions and sustainable practices, aligning with global environmental goals.
7. **Workforce Training and Skill Development:** Develop training programs focusing on Industry 4.0 technologies, such as IoT, big data analytics, and cybersecurity, tailored to the needs of the Blue Economy.

2.6 PROJECT AREA N.6 : PP6 IDA

2.6.1 Overview of SMEs in Blue Economy Sector

The Blue Economy in Istrian County encompasses diverse sectors that leverage the region's rich coastal and maritime resources. The main types of SMEs operating in these sectors, as highlighted in the Word document, include:

Fisheries and aquaculture: SMEs in this sector primarily engage in small-scale fishing and aquaculture activities, focusing on the production of high-quality seafood such as sea bass, sea bream, mussels, and other shellfish. Traditional fishing methods dominate, but there is

potential for digital transformation through IoT and Big Data for stock and environmental monitoring.

Marine tourism: Coastal and marine tourism represents a cornerstone of Istrian County's economy. SMEs include tour operators, nautical tourism providers, eco-tourism businesses, and luxury accommodations. These businesses capitalize on the region's natural beauty, historical sites, and clean waters. Many are beginning to adopt digital marketing tools, AR, and Big Data for personalized and sustainable tourism experiences.

Maritime logistics and port activities: SMEs in maritime logistics manage cargo handling, small-scale port operations, and vessel servicing in regional hubs like Pula. While not as large as other Croatian ports, Istrian logistics SMEs play a critical role in facilitating local trade and supporting the tourism and fisheries sectors. System integration and IoT could significantly improve efficiency in this sector.

Shipbuilding and marine services: Smaller shipyards and marine service SMEs focus on ship repairs, maintenance, and niche shipbuilding. These businesses face challenges with high costs and outdated processes but have opportunities for modernization through IoT, robotics, and simulation tools.

Marine renewable energy: This emerging sector includes SMEs exploring offshore renewable energy solutions, such as wind and solar projects. While still in its infancy in Istria, this sector has strong potential for growth, driven by increasing demand for sustainable energy.

2.6.2 TML Index Results

The average TML score for SMEs across the assessed dimensions places them in the "Basic" to "Average" category, indicating that while some foundational digital tools and processes are in place, there is significant potential for improvement. The typical SME is just beginning its digital transformation journey, with sporadic and unstructured applications of advanced technologies.

Dimension-wise results:

Readiness for Innovation (Average: 30%) - SMEs show moderate awareness of the need for innovation but lack structured R&D efforts and collaboration with research institutions. Investment in intellectual property and advanced research remains limited.

Business Technology Strategy (Average: 40%) - Most SMEs have begun exploring digitalization in key operational areas like administration and logistics. However, strategic planning for company-wide digital adoption remains underdeveloped, and many lack allocated budgets for sustained technological investment.

Digital Readiness (Average: 35%) - SMEs predominantly use traditional digital technologies (e.g., email, spreadsheets, and basic CRM systems), with limited uptake of advanced tools like IoT, AI, and automation. Connectivity between systems is often poor, reducing operational efficiency.

Anthropocentric Digitization (Average: 25%) - There is a general lack of structured training programs to improve workforce digital skills. While awareness of the importance of upskilling is growing, efforts are inconsistent, and employee engagement with digital tools is minimal.

Innovation Barriers (Average: 50%) - Barriers such as high implementation costs, cultural resistance, and limited access to expertise hinder SMEs' ability to adopt advanced technologies. However, many SMEs are open to collaborating with external partners to overcome these challenges.

Insights across the nine I4.0 pillars:

Strengths: SMEs exhibit strength in basic digitization efforts, particularly in administrative and logistics operations, where initial investments have been made. They also show growing openness to external collaboration for overcoming barriers.

Weaknesses: Major gaps exist in R&D investment, workforce digital skills, and connectivity between systems. The uptake of advanced technologies like AI, IoT, and robotics remains minimal due to financial and cultural constraints.

2.6.3 Key Challenges

SMEs in the Blue Economy sectors in Istrian County face several region-specific challenges that limit their ability to improve their Technology Maturity Level (TML) scores and adopt Industry 4.0 principles. These challenges include:

Limited access to advanced digital infrastructure:

- Connectivity gaps: While basic internet connectivity is widely available, high-speed and reliable digital infrastructure required for advanced technologies (e.g., IoT and real-time data sharing) is limited in rural and coastal areas of Istria.
- Inadequate technology ecosystem: There is a lack of local providers offering affordable and scalable Industry 4.0 solutions tailored to the needs of SMEs in Blue Economy sectors.

Skills gaps and workforce readiness:

- Lack of digital skills: Many SMEs struggle to upskill their workforce to adapt to digital tools such as IoT, Big Data, and robotics. Employees often lack even basic digital competencies, creating resistance to new technologies.
- Shortage of expertise: Istria faces a limited pool of technical experts and consultants who specialize in Industry 4.0, making it difficult for SMEs to access guidance and training.

Financial constraints:

- High cost of implementation: The cost of adopting advanced technologies like automation, IoT, and AI is prohibitive for many SMEs, particularly smaller, family-run businesses that dominate the Blue Economy in Istria.
- Limited funding access: SMEs struggle to secure funding for digital transformation projects, as many are unaware of or find it difficult to navigate national and EU funding opportunities (e.g., ERDF, InvestEU, ESM Fund 2025).

Fragmented collaboration and networking:

- Lack of local DIHs: While initiatives like the Istrian Development Agency (IDA) provide some support, the lack of a well-established regional network of Digital Innovation Hubs (DIHs) limits access to resources, training, and partnerships.
- Insufficient cross-border cooperation: Opportunities for collaboration with neighboring Italian regions, especially in shared marine industries, are underutilized, reducing innovation potential.

Cultural and organizational resistance:

- Reluctance to change: Many SMEs are hesitant to adopt digital solutions due to a preference for traditional business practices. Leaders often view digitalization as a cost rather than an investment.
- Lack of strategic vision: Few SMEs have a long-term business strategy that integrates digital transformation, leading to ad-hoc and uncoordinated adoption efforts.

2.6.4 Recommendations for Improvement

Efforts should focus on establishing a regional Digital Innovation Hub (DIH) providing SMEs with advanced digital tools, consulting services, and networking opportunities. Workforce readiness can be enhanced through targeted training programs on IoT, AI, robotics, and data analytics, utilizing platforms like the Digital Skills and Jobs Platform and the Learning Factory for Digital Competitiveness. Leadership workshops for SME owners and apprenticeship programs with universities should further support workforce digitalization.

Funding access needs improvement through campaigns promoting EU programs such as ERDF, ESM Fund 2025, EIC Accelerator, and InvestEU. Regionally, grant schemes modeled after Istrian County's Digital Transformation Grants can subsidize technology adoption. Public-private partnerships (PPPs) should co-finance projects, combining government backing with private sector innovation.

Collaboration is crucial. Establishing a cross-border DIH network with neighboring Italian regions can share resources, training, and expertise. Partnerships between SMEs and

research institutions can foster innovation in fisheries, logistics, and tourism, while regional forums can promote knowledge sharing and best practices.
Cultural barriers must also be addressed. Success stories from local SMEs can inspire others to embrace change, while tax incentives and funding for early adopters can encourage broader participation. Consulting services through IDA or DIHs can help SMEs create digital transformation roadmaps tailored to their needs.

2.7 PROJECT AREA N.7 : PP DIH

2.7.1 Overview of SMEs in Blue Economy Sector

Šibenik-Knin County, situated along the Adriatic coastline of Croatia, is deeply embedded within the Blue Economy, leveraging its natural maritime resources for economic development. This region, renowned for its rich biodiversity, pristine waters, and historic maritime traditions, hosts a diverse range of small and medium-sized enterprises (SMEs) operating across multiple Blue Economy sectors.
Fisheries and Aquaculture: The fisheries sector plays a significant role in the region's economy. Local SMEs focus on traditional fishing methods, emphasizing sustainability and the use of small-scale vessels. Aquaculture, particularly the farming of Adriatic fish species like sea bass and sea bream, is also prevalent, supported by the region's favorable water quality and conditions.
Marine Tourism: Marine tourism is a cornerstone of Šibenik-Knin County's economy, driven by its numerous islands, clear waters, and historical landmarks. SMEs in this sector include charter companies offering sailing and yachting experiences, diving centers catering to underwater exploration, and eco-tourism initiatives emphasizing sustainable practices. The sector thrives due to high demand from international visitors seeking unique maritime experiences.
Maritime Logistics and Transport: The county's strategic location along the Adriatic Sea positions it as an essential hub for maritime logistics and transport. SMEs in this area provide port services, cargo handling, and coastal shipping solutions. Local ports, such as those in Šibenik, facilitate both domestic and international trade, further bolstering the region's maritime economy.
Shipbuilding and Marine Technology: Although smaller in scale compared to other sectors, shipbuilding and marine technology SMEs contribute significantly to innovation within the Blue Economy. These businesses focus on building and maintaining small vessels, as well as developing marine engineering solutions tailored to the region’s specific needs.

Environmental and Renewable Energy Initiatives: A growing number of SMEs in Šibenik-Knin County are engaging in environmental services and renewable energy projects, such as offshore wind and solar installations. These businesses align with broader efforts to ensure the sustainable management of marine and coastal resources, supporting long-term economic and environmental resilience.

Overall, the SMEs operating within Šibenik-Knin County's Blue Economy sectors exemplify a blend of traditional maritime practices and modern, innovative approaches. Their contributions are pivotal in driving sustainable development and creating employment opportunities in this vibrant coastal region.

2.7.2 TML Index Results

The Technological Maturity Level (TML) Index results for SMEs in Šibenik-Knin County reveal moderate progress in adopting Industry 4.0 principles. The overall average TML score for this project area is categorized as **"Moderate"**, indicating room for improvement in leveraging advanced technologies.

Dimension Analysis:

1. **Readiness for Innovation:** SMEs scored **low to moderate**, reflecting limited investment in R&D and innovation.
2. **Business Technology Strategy:** Scores were **moderate**, showing an awareness of technology's strategic importance but gaps in implementation.
3. **Digital Readiness:** Results were **low**, hindered by poor digital infrastructure and technical skills.
4. **Anthropocentric Digitization:** SMEs scored **moderate**, emphasizing the need for workforce training to fully integrate digital tools.
5. **Innovation Barriers:** A high prevalence of external challenges, such as regulatory compliance and financial constraints, reduced scores in this dimension.

The analysis highlights specific strengths, such as strategic awareness in logistics and tourism, but underscores weaknesses in digital readiness and workforce skills.

2.7.3 Key Challenges

Challenges in Šibenik-Knin County's Blue Economy Sector

Despite the significant potential of the Blue Economy in Šibenik-Knin County, several challenges hinder the development and performance of small and medium-sized enterprises (SMEs) in the region. These barriers impact the ability of local businesses to achieve optimal Technological Maturity Levels (TML), which are critical for competitiveness and innovation. Key challenges include:

Limited Access to Digital Infrastructure: While digital transformation is essential for advancing business operations, many SMEs in Šibenik-Knin County face limited access to high-quality digital infrastructure. Rural and coastal areas, particularly those on smaller islands, often struggle with unreliable internet connectivity, impeding the adoption of modern technologies and digital tools necessary for growth.

Skills Gaps and Workforce Development: The region faces a shortage of skilled labor in key sectors of the Blue Economy, including marine technology, aquaculture, and maritime logistics. This skills gap is exacerbated by an aging workforce, limited availability of specialized training programs, and challenges in attracting younger talent to maritime industries. As a result, SMEs may struggle to implement innovative practices or scale their operations effectively.

Financial Constraints: Access to financing is a significant challenge for many SMEs in the county. High dependency on seasonal tourism creates cash flow inconsistencies, while smaller enterprises often face difficulties in securing loans or investment for modernization and expansion. Limited awareness of or access to EU funding opportunities further restricts the financial resources needed for long-term growth.

Fragmentation and Collaboration Barriers: The Blue Economy in Šibenik-Knin County consists of numerous small-scale enterprises operating independently. A lack of coordination and collaboration among these businesses can hinder collective progress, particularly in areas like supply chain optimization, joint marketing efforts, and shared research initiatives.

Environmental and Regulatory Challenges: Strict environmental regulations, while necessary for sustainability, can pose challenges for SMEs in terms of compliance costs and administrative burdens. Additionally, climate change-related impacts, such as rising sea temperatures and extreme weather events, directly affect sectors like fisheries, aquaculture, and marine tourism, increasing operational uncertainties.

Insufficient Innovation Support: The region lacks adequate support structures for fostering innovation among SMEs. Limited access to research and development facilities, partnerships with academic institutions, and innovation hubs constrains the ability of businesses to explore and implement advanced solutions that could enhance their TML scores.

Addressing these challenges will require targeted interventions, such as improved digital infrastructure, workforce training programs, access to financial support mechanisms, and enhanced collaboration between stakeholders. Overcoming these barriers is essential for unlocking the full potential of Šibenik-Knin County's Blue Economy and driving sustainable, inclusive growth in the region.

2.7.4 Recommendations for Improvement

To enhance the TML scores and overall technological readiness of SMEs in Šibenik-Knin County, the following recommendations are proposed:

1. **Digital Infrastructure Development:** Invest in improving internet connectivity, particularly in rural and coastal areas, to enable access to digital tools and platforms.
2. **Workforce Training and Skill Development:** Develop training programs focusing on Industry 4.0 technologies, such as IoT, big data analytics, and cybersecurity, tailored to the needs of the Blue Economy.
3. **Access to Funding:** Facilitate SME access to EU grants and regional financial support mechanisms to fund technological upgrades and innovation.
4. **Innovation Hubs and Partnerships:** Establish regional innovation hubs that foster collaboration between SMEs, academic institutions, and technology providers.
5. **Awareness Campaigns:** Conduct awareness initiatives to educate SMEs about the benefits of digital transformation and available funding opportunities.
6. **Regulatory Support:** Simplify compliance processes and provide SMEs with guidance on navigating environmental and maritime regulations.
7. **Sustainability Initiatives:** Promote the adoption of renewable energy solutions and sustainable practices, aligning with global environmental goals.

By addressing these recommendations, the region can significantly improve its TML scores, fostering a more innovative, competitive, and sustainable Blue Economy ecosystem.

2.8 PROJECT AREA N.8 : PP8 PFRI

2.8.1 Overview of SMEs in Blue Economy Sector

Primorsko-Goranska County, located along Croatia's northern Adriatic coast, is renowned for its stunning coastal landscapes, numerous islands, and vibrant maritime economy. The county plays a key role in the Blue Economy, encompassing sectors such as shipbuilding, fisheries, tourism, renewable energy, innovation, and IT. These sectors, when aligned with sustainable development principles, hold immense potential for fostering regional economic growth and environmental preservation.

Shipbuilding

With a long-standing tradition, the shipbuilding industry continues to be a cornerstone of the region's economy. Modernization efforts have led to the adoption of energy-efficient vessel designs, environmentally friendly materials, and emission-reducing technologies.

These innovations enhance sustainability and global competitiveness, ensuring the industry's resilience in the face of environmental and market changes.

Fisheries and Aquaculture

These sectors are essential contributors to the local economy but face challenges such as overfishing and marine ecosystem degradation. By embracing advanced aquaculture technologies, sustainable fisheries management, and environmentally friendly practices, the county can ensure the long-term viability of these industries while safeguarding marine biodiversity.

Tourism

Tourism is a key economic driver in Primorsko-Goranska County, leveraging its cultural heritage, natural beauty, and diverse coastal attractions. However, to sustain growth, tourism must transition towards eco-tourism models that prioritize environmental preservation, reduce over-tourism in sensitive areas, and involve local communities in decision-making processes.

Renewable Energy

The county is at the forefront of exploring renewable energy sources, such as solar, wind, and wave energy, which align with its Blue Economy goals. Investments in renewable energy infrastructure are helping reduce greenhouse gas emissions, promote energy independence, and support the region's transition to a low-carbon economy. Wave energy technologies, in particular, are being researched for their potential to complement traditional renewable sources and harness the vast energy of the Adriatic Sea.

Innovation and IT Industry

The presence of a dynamic innovation ecosystem and a thriving IT industry significantly strengthens the county's economic landscape. IT companies in the region are actively driving digital transformation across Blue Economy sectors, including maritime transport, fisheries, shipbuilding, and tourism. Advanced data analytics, Internet of Things (IoT) applications, and artificial intelligence (AI) are enabling SMEs to optimize operations, improve resource management, and enhance customer experiences. Moreover, the innovation ecosystem fosters collaboration between SMEs, universities, and research centers, facilitating the development of groundbreaking solutions for sustainable economic growth.

Digital tools and platforms are transforming traditional industries in the county. For instance, the use of digital mapping and predictive analytics in fisheries can optimize resource use, while augmented reality (AR) and virtual reality (VR) technologies are being adopted in tourism to create immersive visitor experiences. Expanding the digital capabilities of SMEs

through training and infrastructure investments will be crucial for maintaining the county's competitive edge.

2.8.2 TML Index Results

The Technology Maturity Level (TML) Index for SMEs in Primorsko-Goranska County reveals an overall "Moderate Advanced" level of technological maturity. This assessment indicates that while progress has been made, there are still gaps in digital readiness and the adoption of Industry 4.0 technologies.

Results by Dimensions

1. **Innovation Readiness:** Moderate readiness, with IT and innovation industries leading, but traditional sectors like fisheries and tourism needing additional support.
2. **Business Technology Strategy:** Uneven adoption, with strong strategies in IT but a lack of structured technology roadmaps in traditional industries.
3. **Digital Readiness:** Low adoption of digital tools in sectors like tourism and fisheries underscores the need for significant improvements.
4. **Anthropocentric Digitization**: Limited workforce digital skills, especially in traditional sectors, remain a significant challenge.
5. **Innovation Barriers:** Funding and infrastructure limitations, coupled with resistance to change, continue to hinder technological progress.

Strengths and Weaknesses

Strengths

- Research and IT firms are highly skilled in business technology strategy and nnovation readiness.
- Some SMEs have advanced in their digital integration, especially in using simple tools to increase operational effectiveness.

Weaknesses:

- Two major shortcomings in the tourism and fishing industries are workforce training and digital readiness.
- Wider technological maturity is constrained by high barriers to innovation, such as insufficient infrastructure and funding.
- Poor automation and IoT adoption scores point to the need for focused assistance with cutting-edge I4.0 technologies

2.8.3 Key Challenges

Despite the significant potential of the Blue Economy in Split-Dalmatia County, several challenges prevent SMEs from achieving optimal Technological Maturity Levels (TML).
These challenges, as reflected in the TML index results and regional analysis, include:

1. Limited Funding: SMEs struggle to access financing for innovation, digitalization, and sustainable development.

2. Inadequate Infrastructure: Rural and coastal areas lack robust digital connectivity, while transportation infrastructure requires modernization.

3. Skills Gaps: There is a shortage of digitally skilled workers, particularly in traditional industries such as fisheries and tourism.

4. Collaboration Deficit: Weak ties between SMEs, research institutions, and IT companies reduce opportunities for innovation.

5. Resistance to Change: Cultural barriers and limited awareness among SMEs about the benefits of digital transformation hinder progress

2.8.4 Recommendations for Improvement

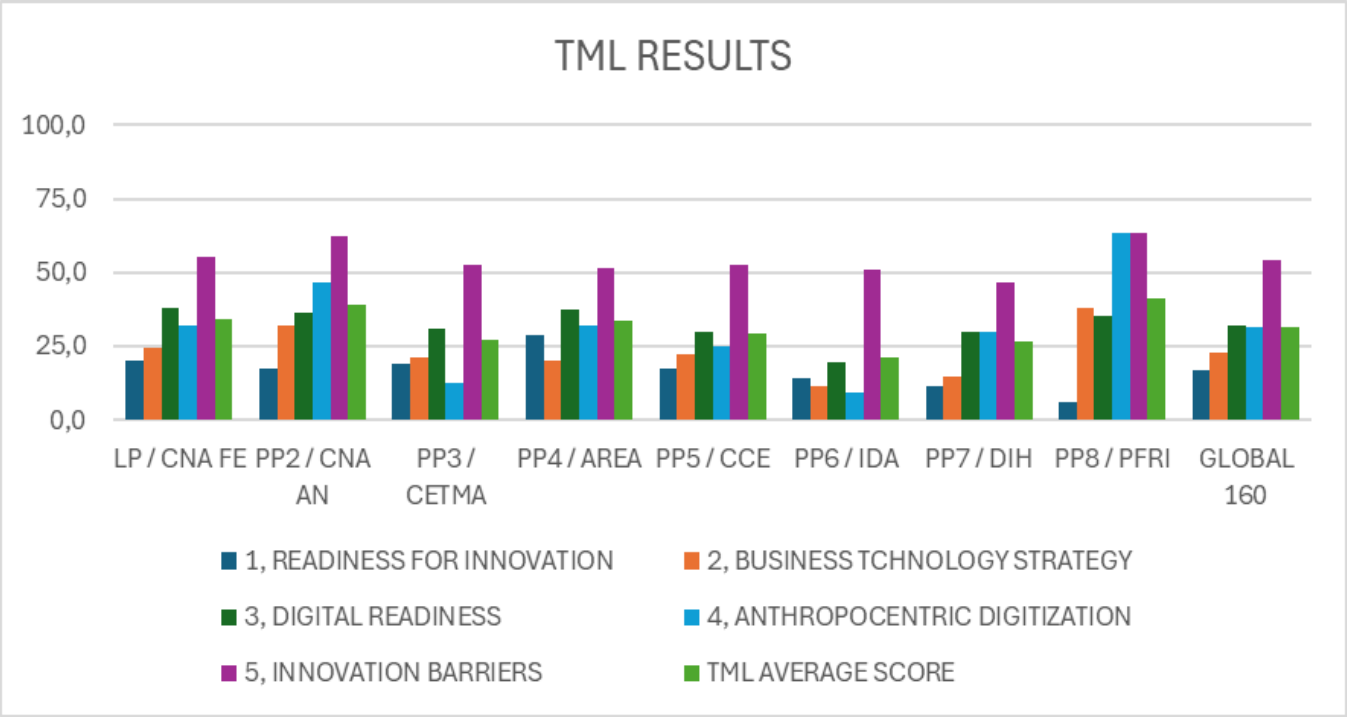
To address the challenges facing the development of the Blue Economy and the technological maturity of SMEs in Split-Dalmatia County, the following recommendations for improvement are proposed:

1. Facilitate Access to Funding: Strengthen SME access to EU grants and regional financing mechanisms to support innovation, digital transformation, and sustainability initiatives.
2. Improve Digital Infrastructure: Invest in high-speed internet and digital tools in rural and coastal areas to enable SME participation in Industry 4.0.
3. Promote Workforce Development: Launch targeted training programs to enhance workforce skills in advanced technologies such as AI, IoT, and big data.
4. Foster Collaboration: Establish innovation hubs to facilitate partnerships between SMEs, research institutions, and technology providers, driving knowledge exchange and joint projects
5. Launch Awareness Campaigns: Educate SMEs about the economic and environmental benefits of digital transformation and Industry 4.0 adoption.
6. Support Renewable Energy Development: Expand initiatives for solar, wind, and wave energy adoption, promoting energy independence and environmental sustainability.
7. Encourage IT Industry Growth: Provide incentives for IT companies to collaborate with traditional sectors, enhancing their digital maturity and fostering innovation-driven growth.

3. COMPARATIVE ANALYSIS OF TML INDEX ACROSS PROJECT AREAS

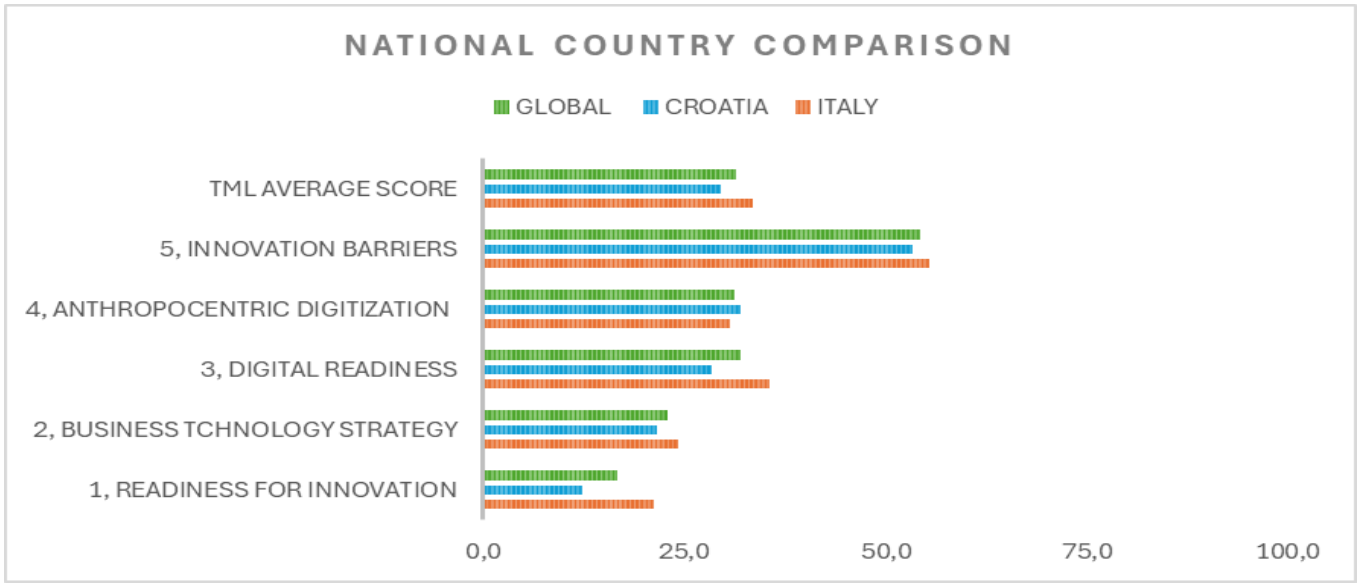
3.1 Summary of Results

The comparative analysis of the Technology Maturity Level (TML) Index across the eight project areas provides a clear picture of the digital readiness and Industry 4.0 (I4.0) maturity of SMEs operating in the Blue Economy. The following graph and table summarize the average TML scores for each project area, highlighting strengths and gaps in technological adoption.

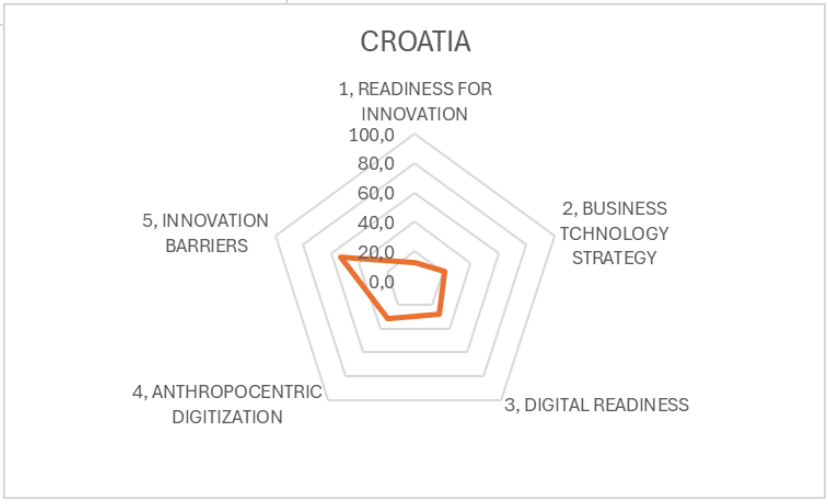


TML SCORE AND LEVEL

0/5	INITIAL
6/25	BASIC
26/50	AVERAGE
51/75	MODERATELY ADVANCED
76/100	ADVANCED


NATIONAL COUNTRY COMPARISON
GLOBAL
CROATIA
ITALY
TML AVERAGE SCORE
5, INNOVATION BARRIERS
4, ANTHROPOCENTRIC DIGITIZATION
3, DIGITAL READINESS
2, BUSINESS TCHNOLOGY STRATEGY
1, READINESS FOR INNOVATION
0,0
25,0
50,0
75,0
100,0


ITALY
1, READINESS FOR INNOVATION
100,0
80,0
60,0
40,0
20,0
0,0
2, BUSINESS TCHNOLOGY STRATEGY
3, DIGITAL READINESS
4, ANTHROPOCENTRIC DIGITIZATION
5, INNOVATION BARRIERS


CROATIA
1, READINESS FOR INNOVATION
100,0
80,0
60,0
40,0
20,0
0,0
2, BUSINESS TCHNOLOGY STRATEGY
3, DIGITAL READINESS
4, ANTHROPOCENTRIC DIGITIZATION
5, INNOVATION BARRIERS

Project Area	Highest-Scoring Dimension	Lowest-Scoring Dimension
Emilia-Romagna / LP	Digital Readiness	Readiness for Innovation
Marche / PP2	Anthropocentric Digitization	Readiness for Innovation
Puglia / PP3	Digital Readiness	Anthropocentric Digitization
Friuli Venezia Giulia /PP4	Digital Readiness	Business Technology Strategy
Split-Dalmatia / PP5	Digital Readiness	Readiness for Innovation
Istrian County / PP6	Digital Readiness	Anthropocentric Digitization
Šibenik-Knin County / PP7	Anthropocentric Digitization	Readiness for Innovation
Primorsko-Goranska County /PP8	Anthropocentric Digitization	Readiness for Innovation

3.2 Key Trends and Insights

The analysis of TML Index scores across the eight project areas highlights key trends in SMEs' Industry 4.0 (I4.0) readiness within the Blue Economy. A notable pattern is the disparity in digital maturity levels among regions, with Emilia-Romagna, Split-Dalmatia, and Primorsko-Goranska County demonstrating relatively higher technological readiness, whereas areas like Istrian County and Puglia exhibit more limited adoption of advanced digital solutions.

Among the five assessed dimensions, **Digital Readiness** emerged as the strongest across multiple project areas, reflecting SMEs' growing awareness and initial efforts toward digital transformation. However, significant gaps remain in **Readiness for Innovation** and **Anthropocentric Digitization**, with many SMEs struggling to integrate structured innovation strategies and workforce upskilling programs.

Key barriers include **limited access to financial resources, lack of skilled personnel, and technological fragmentation**. SMEs in traditional sectors such as **fisheries, tourism, and shipbuilding** tend to lag behind in adopting advanced Industry 4.0 technologies, whereas IT-driven enterprises and research institutions demonstrate greater technological adaptability.

Potential areas for cross-border collaboration and knowledge sharing include:

- **Workforce training and upskilling programs** to enhance digital competencies, particularly in AI, IoT, and data analytics.
- **Joint R&D initiatives** between SMEs and research institutions to foster innovation in sustainable maritime technologies.
- **Cross-border digital platforms and data-sharing mechanisms** to improve supply chain integration and industry-wide transparency.
- **Collaborative investment frameworks** to support SMEs in overcoming financial and infrastructural barriers to digital transformation.

By fostering these collaborations, regions can collectively enhance their Blue Economy digital ecosystem, ensuring sustainable and resilient economic growth.

4. CONCLUSION

4.1 Summary of Findings

The TML Index analysis highlights that SMEs across the project areas exhibit varying levels of Industry 4.0 readiness. Digital readiness emerges as a strength, indicating SMEs recognize the need for digital transformation. However, readiness for innovation remains a major bottleneck, with workforce skills, financial constraints, and regulatory barriers limiting the adoption of advanced technologies.

The TML Index analysis provides a comprehensive overview of SMEs' digital transformation progress in the Blue Economy. Key findings include:

- **Uneven digital readiness:** While some regions, such as Emilia-Romagna and Split-Dalmatia, exhibit moderate to advanced digital adoption, others, like Istrian County and Puglia, still face substantial challenges.
- **Sectoral disparities:** IT-related and research-driven SMEs show stronger digital integration, whereas traditional sectors (fisheries, tourism, and shipbuilding) struggle with limited technological adoption.
- **Innovation and workforce gaps:** Many SMEs lack structured R&D strategies and digital training programs, resulting in slow technological uptake.
- **Common challenges across regions:** Financial constraints, regulatory complexity, and digital infrastructure limitations are prevalent across all project areas, hindering technological progress.

Despite these challenges, there is substantial **growth potential** through cross-sectoral collaboration, targeted financial support, and enhanced training programs.

4.2 Path Forward

To enhance technology maturity and foster a robust cross-border Blue Economy ecosystem, a strategic roadmap should focus on:

1. **Improving Digital Infrastructure:** Investments in high-speed internet and cloud-based platforms to enable SMEs to adopt Industry 4.0 technologies seamlessly.
2. **Developing Workforce Skills:** Implementing cross-border digital literacy and upskilling programs in AI, IoT, and cybersecurity tailored to maritime and coastal industries.
3. **Strengthening Financial Support:** Expanding access to EU and national funding programs, tax incentives, and venture capital investment to enable SMEs to adopt advanced technologies.
4. **Encouraging Innovation Hubs:** Establishing digital innovation hubs and accelerators focused on the Blue Economy, facilitating collaboration between SMEs, academia, and technology providers.
5. **Promoting Sustainable Digital Transformation:** Aligning digital initiatives with environmental sustainability goals, integrating green technologies into maritime logistics, fisheries, and tourism.
6. **Enhancing Cross-Border Collaboration:** Establishing regional networks for SMEs to exchange best practices, share digital solutions, and engage in joint R&D projects.

By addressing these critical areas, the Blue Economy can advance toward a **more digitalized, sustainable, and resilient** future, ensuring economic competitiveness and long-term ecological balance in the evolving global market..

Appendices

Companies' check-up reports

Scan the QRcode or click on the link to see a short presentation of all the answers collected from the PPs by interviewing companies in the assessment phase
https://forms.office.com/e/PsayiBPZGJ?origin=lprLink