

2025 APEC International Seminar on the Application of Smart Technology to Textile Industry

APEC Policy Partnership on Science, Technology and Innovation

April 2026



**Asia-Pacific
Economic Cooperation**



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KEY ABBREVIATIONS

Abbreviations	Meaning
AI	Artificial Intelligence
APEC	Asia-Pacific Economic Cooperation
AWI	Australian Wool Innovation
AWTH	Australian Wool Traceability Hub
BCI	Better Cotton Initiative
CBPR	Cross-Border Privacy Rules
CBV	Core Business Vocabulary
COVID	Coronavirus Disease 2019
CRM	Customer Relationship Management
DPP	Digital Product Passport
ERP	Enterprise Resource Planning
ESG	Environment, Social Responsibility and Corporate Governance
ESPR	Eco-design for Sustainable Products Regulation
EU	European Union
FDI	Foreign Direct Investment
GHG	Greenhouse Gas
ILO	International Labour Organization
IoT	Internet of Things
ISO	International Organization for Standardization

1. Current Situation of Supply Chain Monitoring Solutions for Cross-Regional Sites

1.1 Overview of Global and Regional Supply Chains

In the context of the contemporary global economic system, supply chains are not merely linear sequences of production stages from upstream to downstream, but rather complex networks of organizations and activities that are interconnected across borders. These networks involve the systematic flow of raw materials, information, and capital from sources of raw materials and manufacturing plants through wholesalers and retailers to the final consumers.

From the perspective of the textile and apparel industry, a typical supply chain begins with fibers, proceeds to spin into yarn, weaving or knitting into fabric, and then to garment manufacturing into finished apparel. This is followed by distribution to retail outlets and ultimately delivery to the end user. At each stage, there is a reverse flow of cash from consumers back to producers, as well as a continuous flow of information between producers and the market. Such information enables more efficient planning of production, procurement, distribution, and investment (Jana, 2010).

For the Asia–Pacific region, particularly among APEC member economies, the textile and apparel industry constitutes one of the manufacturing sectors whose supply chains are deeply integrated into global supply chains. The region functions both as a major production base and as an export platform serving key markets such as Japan; the United States; and the European Union. Consequently, the structure of textile supply chains represents a critical component of free trade arrangements, cross-border investment, and broader economic development efforts that aim to promote sustainability and reduce environmental impacts.

Among APEC member economies, the value of textile and apparel exports has increased continuously since the mid-1990s, reflecting the fact that APEC has become one of the world’s key centers of textile production and export. This growth is closely associated with the expansion of production supply chains in Asia, trade liberalization, and the rising demand in global markets, particularly from consumers in Japan; the United States; and the European Union.

Table 1: Value of Textile and Apparel Exports from APEC Economies

Year	Value of Textile and Apparel Exports from APEC Economies (million US dollars)
1995	31.190
2000	38.072
2005	66.161
2010	103.485
2015	142.763
2020	157.025

Source: APEC Committee on Trade and Investment (2024)

However, the textile industry is also one of the manufacturing sectors that exerts substantial pressure on the environment, in terms of greenhouse gas emissions, intensive water and chemical use in dyeing and finishing processes, the generation of textile waste and microplastics, and dependence on fossil energy. As major markets such as Japan; the United States; and the European Union have tightened environmental standards and requirements for supply chain transparency, textile producers in APEC economies are increasingly compelled to transition toward greener production and to strengthen their traceability capabilities in parallel.

At the same time, digital technologies and artificial intelligence are being applied more widely in the textile industry, including for machine condition monitoring and predictive maintenance, supply chain management, demand forecasting, and mass customization. These applications aim to enhance efficiency, reduce costs, and respond to the rapidly changing dynamics of the fashion market (ITMF, 2024). In addition, several APEC member economies, such as Chile; People’s Republic of China; Indonesia; the Philippines; and Thailand, have adopted policies and initiatives that support the transition toward circular and green economic models, as well as the reduction of dependence on traditional linear resource use.

1.2 Geographical Dispersion Trends in Textile Supply Chains

In recent years, textile supply chains have experienced gradual geographical reconfiguration driven by a combination of geopolitical uncertainties, evolving trade and regulatory environments, and shifting cost and capability conditions. In response, manufacturers and brands have increasingly adopted multi-location sourcing and production strategies to diversify operational risks and enhance supply continuity. As a result, production networks have become more geographically dispersed across Asia, with Southeast Asia emerging as an increasingly important hub for manufacturing, logistics connectivity, and supporting services. In parallel, established manufacturing

centers have continued to move toward higher value-added activities, including technical textiles and more advanced automation, reflecting an ongoing transition in industrial positioning.

From an economic opportunity perspective, the textile industry in the Asia-Pacific region constitutes a market worth several hundreds of billions of US dollars and is projected to continue expanding through 2030. Key drivers include rising incomes and purchasing power among the urban middle class, growing demand for high quality fashion and environmentally friendly products, the expansion of e-commerce, and the trend toward relocating production closer to consumer markets in ASEAN and India. These dynamics create opportunities to upgrade value added across all stages of the supply chain, from raw materials and manufacturing to logistics and retail platforms. Nevertheless, the textile sector in APEC economies continues to face significant challenges, including rising production costs, mounting environmental pressures and stricter sustainability standards, the complexity of cross border supply chains, and technological gaps between large firms and SMEs. As a result, efforts to raise ESG standards, reduce carbon footprints, and promote circular economy models serve both as a source of pressure for adjustment and as a window of opportunity for enterprises that can invest in clean technologies, traceability systems, and sustainable product design to build long term competitive advantage.

1.3 Significance of Supply Chain Monitoring in Cross-Regional Contexts

Supply chain monitoring systems have evolved from being merely supporting tools to becoming strategic infrastructure for cross-border business operations, particularly in industries that rely heavily on natural resources and large labor forces, such as agriculture, forestry, and textiles. The core objective is to ensure that information on product origin, production processes, transportation, and environmental impacts is transparent, verifiable, and interoperable under harmonized standards.

The European Union and international standard-setting bodies have introduced new laws and standards that compel companies to strengthen their monitoring systems. These rules apply both to firms located in Europe and to trading partners from other regions that seek to export to the European market. As a result, Asian and APEC economies, in their role as the factory of the world, are required to adjust their supply chain information systems to comply with these requirements. Failure to meet expectations regarding traceability, information disclosure, and ESG reporting may lead to restricted market access and significantly higher trade and financing costs.

1.3.1 The Necessity of Traceability and Transparency in Supply Chains

A key driving force behind the emergence of traceability as a core element of cross-regional supply chain management is the proliferation of laws and international standards that require companies to conduct supply chain due diligence on human rights and environmental risks throughout their value chains. Industries exporting to the European Union must demonstrate evidence of the origin of raw materials, production conditions, and impacts on forests and ecosystems under the EU Deforestation Regulation (EUDR) and the Corporate Sustainability Due Diligence Directive (CSDDD); otherwise, their products may be rejected or face higher trade and financing costs.

The concept of a Digital Product Passport (DPP), introduced under the Ecodesign for Sustainable Products Regulation (ESPR), for goods such as textiles and garments further underscores that information on the product life cycle from design and manufacturing to use and end-of-life management must be recorded and linked at the unit level and be interoperable across borders. In this context, data standards such as EPCIS/CBV and Chain of Custody standards play a critical role in ensuring that information on the movement of goods and the transfer of ownership along the supply chain can be reliably traced and exchanged.

1.3.2 Risk Management, Resilience, and Crisis Response

Supply chain monitoring systems play a critical role in risk management and in building supply chain resilience amid increasingly complex crises, including pandemics, climate-related disasters, political conflicts, and border closures. These events have exposed the multi-layered vulnerabilities of otherwise invisible segments of supply chains, particularly when firms lack in-depth information about lower-tier suppliers (tier 2, tier 3) and the actual transportation routes used. Disruptions at any single node can, therefore, trigger cascading effects across the entire system.

In response, modern supply chain monitoring systems are designed to integrate data from multiple sources such as production information, multimodal transport data, and inputs from IoT devices to enable firms to visualize inventory status, transport routes, and network risks in real time. Standards frameworks such as ISO 28000:2022 provide a structured approach to harmonizing risk management practices across organizations and regions, thereby facilitating more systematic and timelier implementation of contingency planning, route adjustments, and supplier substitution.

1.3.3 The Role of Monitoring Systems in Advancing the Circular Economy and ESG

From a sustainability perspective, supply chain monitoring systems function as a field-level data infrastructure that underpins both the transition toward a circular economy and compliance with increasingly stringent ESG criteria worldwide. Corporate sustainability reporting measures, such as the European Union's reporting frameworks, require companies to disclose information on environmental, social, and governance impacts across the entire value chain, which in practice means drawing data from multiple tiers of suppliers and business partners, rather than focusing solely on in-house operations.

With respect to greenhouse gas mitigation, international standards such as the GHG Protocol, particularly Scope 3 that define methods for assessing emissions from upstream and downstream activities across 15 categories. Implementing these frameworks in practice requires quantitative, geolocation, and activity data that can be traced back through cross border supply chains. In terms of sector specific regulations, instruments such as the European Union's deforestation free products regulation oblige key forest and agricultural commodities to demonstrate that their origin is not associated with deforestation, from production through to final consumption. At the same time, circular economy legislation, including the Eco-design for Sustainable Products Regulation (ESPR) and the Digital Product Passport (DPP) framework, drives demand for increasingly granular product life-cycle information from design and material selection through use, reuse, repair, disassembly, and recycling. For certain product groups, such as textiles and apparel, the rollout of DPP requirements under secondary legislation between 2025 and 2030 will therefore depend heavily on supply chain monitoring systems capable of consistently collecting and linking product-level data from diverse actors across multiple regions.

1.4 Existing Monitoring Technologies and Solutions

1.4.1 Key Technologies Relevant to the Textile Industry

Radio Frequency Identification (RFID) technologies, particularly ultra-high-frequency (UHF) or RAIN RFID systems, constitute a core solution for item identification at scale. They enable simultaneous reading of many tags without requiring direct line-of-sight to the code, making them well suited for inventory counting, inbound and outbound goods handling, and synchronizing stock data between warehouses and retail outlets in omnichannel systems. Although their deployment requires investment in infrastructure and adjustments to existing operational processes, RFID solutions can significantly improve accuracy and reduce losses in inventory

management.

Two-dimensional code technologies (QR codes and 2D barcodes), together with the GS1 Digital Link standard, provide another key foundation for linking product information to digital databases. Such codes can be printed on neck labels, care labels, or hang tags and used both for internal management purposes and for communicating information to consumers, for example, the origin of raw materials, product composition, environmental impacts, and concepts related to the Digital Product Passport. A major advantage is their low cost and the fact that they can be read using ordinary smartphones, making them particularly suitable for enhancing transparency at the consumer level.

Internet of Things (IoT) technologies including sensors, tracking devices, and smart cameras enable real-time collection of data on the location and environmental conditions of products, both along production lines and during transportation. Data on temperature, humidity, and vibration can be integrated with production planning and logistics systems to support quality control, reduce waste, and enhance the flexibility of supply chains.

Blockchain technologies and digital identity systems are used to establish more reliable traceability databases by recording key events and certifications at each stage of production and trade in ledgers that are difficult to tamper with retroactively. When combined with physical identifiers embedded in fibers or fabrics, these systems help verify the origin of materials and production pathways, reduce the risk of fraud, and support compliance with human rights and international trade regulations.

Cloud-based supply chain management (SCM) and network platforms function as shared infrastructure for connecting data among multiple stakeholders within a single system from production planning and order management to transport tracking and linkages with financial supply chains. These platforms enable firms to obtain an integrated overview of cross-border supply chains and to respond more promptly to risks or volatility.

1.4.2 Practical Applications in Manufacturing Plants, Importers, Distributors, and Retailers

Manufacturing plants: RFID and IoT technologies are used to control the flow of raw materials and semi-finished goods within factories by attaching tags to fabrics, yarns, or transport containers to record production status at each control point. These

are complemented by sensors and AI-enabled cameras on production lines for automatic fabric quality inspection. Together, these technologies enable factories to reduce waste, analyze machine utilization in real time, and transmit such data to cloud platforms for network-level production and delivery planning.

Importers: IoT technologies and cloud platforms enhance the monitoring of goods in transit across regions. For example, tracking devices can collect data on the location and environmental conditions of containers along long-distance transport routes, while this information is integrated with cloud-based SCM systems that consolidate purchase orders, customs documentation, payments, and data from logistics partners. This allows importers to view both the physical status of goods and their documentary status within a single system.

Distributors: Distributors and warehouse service providers can deploy RFID and QR/2D barcodes to improve the efficiency of receiving, storage, and distribution operations. Installing RFID gate readers at warehouse entrances enables rapid counting of large volumes of stock, whereas QR/2D barcodes are well suited to item-level verification, lot tracking, and inventory management requiring high granularity. In cases involving special conditions such as temperature-sensitive products, IoT systems can monitor and record environmental conditions during storage and transportation, thereby reducing the risk of product degradation.

Retailers: RFID technology has been shown to significantly improve the accuracy of in-store inventory data and to support omnichannel strategies, such as reserving products online for in-store pickup or synchronizing stock information across multiple branches. Major fashion retailers deploy RFID across both distribution centers and retail outlets to obtain detailed and concurrent information on product quantities and locations. At the same time, the use of QR codes or GS1 Digital Link enables consumers to scan labels to access information on materials used, carbon emissions, and options for garment take-back and recycling thus aligning with global sustainability trends in the fashion market.

1.5 Key Challenges in Cross-Regional Supply Chain Monitoring

1.5.1 The Complexity of Multi-Tier Supplier Production

Textile supply chains are characterized by multi-stage processes, ranging from raw material production, spinning, weaving, and dyeing to garment manufacturing and product distribution, with activities dispersed across multiple regions. This

configuration gives rise to multi-tier subcontracting structures, particularly in upstream stages such as cotton cultivation in Asia and Africa, where labor and production standards often pose significant risks and are difficult for downstream buyers to monitor (ILO, 2025). Even at the level of garment factories, there is a tendency to subcontract work to smaller, informal producers without disclosing this to the ordering brands, driven by delivery pressure and late-season changes in purchase orders. This increases the number of supplier tiers and creates hidden layers that obscure accurate information on working conditions and production environments (UCLA Anderson Review, 2020; MIT Sloan Management Review, 2020).

At the same time, the growing demand to verify specific raw material attributes such as recycled or organic cotton has led to wider use of chain-of-custody standards to prevent the mixing of other materials for cost-reduction purposes. In the absence of robust traceability systems, there is a heightened risk of original claims that do not reflect reality. Moreover, information on production sites and factory identities is often fragmented, recorded under different names or spellings, and subject to changes in ownership, making it difficult to match the same facility across multiple databases. Open data platforms such as Open Supply Hub are therefore used as centralized facility reference systems to reduce data duplication and enhance transparency across multi-tier production networks (Open Supply Hub, 2022).

1.5.2 Diversity of Data Standards and IT Platforms

The high degree of heterogeneity in data standards and information technology platforms, combined with limited interoperability, poses a significant challenge. Although international frameworks for track-and-trace systems exist—such as GS1 EPCIS/CBV and UN/CEFACT frameworks for multimodal transport—their practical adoption in the private sector and among public authorities remains uneven, both in terms of the number of participating economies and the tiers of the supply chain covered. Consequently, firms must continually convert and reformat data between the systems of trading partners in different regions, increasing information-related costs and the risk of discrepancies (GS1, 2021).

1.5.3 Differences in Digital Development Levels among APEC Economies

The level of digital readiness among APEC member economies varies considerably, with direct implications for their capacity to adopt supply chain monitoring technologies on an industrial scale. According to the GSMA Mobile Connectivity Index (2024), which assesses communication infrastructure, affordability and access, population-wide digital skills, and the robustness of the digital regulatory

framework, economies with high index scores such as Japan; the Republic of Korea; and Singapore are better positioned to advance textile factories toward Industry 4.0 and to enable real-time supply chain data integration than those with medium or low scores, such as, Indonesia; Papua New Guinea; The Republic of the Philippines; and Viet Nam.

At the enterprise level, particularly among micro, small, and medium-sized enterprises (MSMEs) in the textile and garment sector, evidence from the APEC Workshop on Supporting MSMEs' Transition to Circular Economy in Textile and Garment Industries organized by the APEC Small and Medium Enterprises Working Group (2025) indicates that many firms still lack the adoption of key technologies, sector-specific standards, and systematic policy support. As a result, the deployment of technologies such as RFID, IoT, blockchain, and cloud-based systems to enhance cross-regional supply chain traceability remains largely concentrated among major industry players. At the same time, reports by the International Labor Organization (ILO) suggest that the textile industry in the Asia–Pacific region is undergoing a digital transition in the post-COVID-19 context yet continues to face gaps in workforce skills and change management within factories and supplier networks. These constraints hinder the implementation of sophisticated and comprehensive monitoring systems that extend across all ties of the supply chain.

1.5.4 Budget Constraints and Adaptation Challenges of SMEs

Small-scale producers and SMEs in textile supply chains often face constraints in budget, resources, and managerial capabilities, which limit their ability to invest in monitoring and traceability systems. The initial costs of installing tracking devices, upgrading warehouse and information systems, training personnel, and covering other fixed expenses constitute a significant burden that tends to delay traceability-related investments among smaller firms, even though such systems are increasingly a key prerequisite for accessing high-standard markets (OECD, 2024).

Regulatory requirements also place pressure on upstream producers, such as those in agriculture and forestry, who must demonstrate that their production processes are free from deforestation to export to European and other advanced markets. Several policy reports reflect concerns among small producers that per-unit compliance costs, for example, per kilogram of produce are so high that they struggle to compete with larger firms (Reuters, 2025). In many cases, businesses also perceive support measures from governments and international organizations as insufficient. Although APEC has developed various support tools, such as small grants, training programs, and

assessment guidelines to accelerate the digital transition of MSMEs, the scope, continuity, and effective accessibility of these measures remain limited. Consequently, the upgrading of supply chain monitoring systems among SMEs has yet to reach its full potential relative to the increasingly stringent requirements of global markets.

1.6 Comparative Analysis: Regional Readiness and Adoption of Supply Chain Monitoring Systems

A comparative analysis of regional readiness and patterns of adoption of supply chain monitoring systems reveals that each region possesses distinct strengths and limitations in terms of legal and standards infrastructure, technological infrastructure, and human resource capacity. These factors collectively exert a significant influence on the ability to develop and upgrade traceability systems for textile supply chains in cross-regional contexts.

1.6.1 Levels of Readiness in Infrastructure, Technology, and Human Resources

The European Union can be considered the most advanced in terms of readiness, as it has a comprehensive legal and standards framework that clearly sets the direction for the development of monitoring systems. It has also launched major initiatives such as CIRPASS and CIRPASS-2, which aim to develop the infrastructure required for the deployment of Digital Product Passports across multiple industries, drawing on GS1 standards for product identification and life-cycle data linkage. This enables the establishment of end-to-end traceability systems from upstream to downstream in a concrete manner.

By contrast, in the Asia-Pacific region, although there are major producer economies such as People's Republic of China; and India with strong manufacturing bases and supply chain networks, the integration of digital technologies for cross-border data tracking remains limited. Many economies have begun to invest in smart manufacturing, blockchain, and IoT, yet the effective utilization of these technologies is constrained by misaligned data standards and gaps in workforce skills.

North America, particularly Canada and the United States, has achieved a high level of advancement in digital technologies and makes extensive use of RFID, big data, and AI for product tracking. However, the expansion of such systems has been driven primarily by market incentives rather than by a unified regulatory framework. As a result, the region can be regarded as having strong technological readiness but lacking a cohesive set of regulations comparable to those in Europe.

1.6.2 Classification of Economies According to Their Capacity to Adopt Supply Chain Monitoring Systems

Based on a comparative assessment of legal frameworks, international standards, technological capabilities, and human resource capacity, economies can be classified into three groups according to their capacity to adopt supply chain monitoring systems, as follows:

Table 2: Capacity to Adopt Supply Chain Monitoring Systems

Capacity to Adopt Supply Chain Monitoring Systems	Detail
High-capacity group (e.g., Japan; Republic of Korea; and United States)	They have clearly defined legislation or regulatory frameworks that support the use of monitoring systems, are closely aligned with international standards, and possess the requisite technologies and skilled personnel. As a result, members of this group can act as leaders in shaping standards and practices that serve as models at the international level.
Medium-capacity group (e.g., People’s Republic of China; and Viet Nam).	They possess strong and steadily increasing production capacities and investment in digital infrastructure but still need to accelerate the development of data standardization systems, mechanisms for inter-agency integration, and workforce skills to meet international requirements. If these gaps can be closed, members of this group are likely to assume an increasingly important role in global textile supply chains.
Low-capacity group (e.g., Cambodia).	They are predominantly emerging textile-producing economies which, despite enjoying advantages in labor costs, still lack the digital infrastructure, legal frameworks, and standards necessary to support systematic supply chain monitoring. Economies in this group therefore need to rely on technology transfer, standards cooperation, and momentum generated by major trading partners or leading firms within the supply chain to upgrade their production and traceability standards in line with international requirements.

1.6.3 Prospects for Upgrading toward Regional Integration

The potential to upgrade toward regional integration depends on the existence of joint legal frameworks, internationally harmonized standards, and pressures from global markets. The European case illustrates a prototype in which central legislation and the DPP platform function as shared infrastructure for cross-border product data exchange, creating both regulatory and economic incentives to strengthen traceability systems. In the Asia–Pacific region, although levels of readiness vary, existing cooperation frameworks such as customs and logistics data linkages could be further developed toward the integration of sustainability and traceability information, provided that common data standards are established. In North America, despite the absence of a robust regional legal framework, large retail corporations play a pivotal role in setting transparency requirements for suppliers worldwide, which can become a

powerful driver for raising operational standards in practice. In the long term, advancing textile supply chain monitoring toward regionally integrated systems will require parallel progress in legal frameworks, standards, digital technologies, and human resources. This is essential for building traceability systems that are transparent, interoperable across borders, and capable of sustainably enhancing competitiveness in global markets.

2. Policy Recommendations

2.1 Main Objectives of the Policy Recommendations and Strategic Direction for APEC Member Economies

The primary objective of these policy recommendations is to accelerate the transition toward a modern, transparent, and sustainable textile production and supply chain system, without leaving smaller players behind and with due regard to the resource constraints of economies with differing capacities. The proposed policies therefore aim to reduce investment and capability barriers that hinder technology adoption; to build shared regional infrastructure, data, and standards so that domestic systems can genuinely interoperate; and to foster a collaborative ecosystem among governments, producers, distributors, and actors responsible for reverse logistics, textile waste management, and material recovery, in alignment with extended producer responsibility (EPR) frameworks. By explicitly recognizing these distinct yet interconnected stakeholders, the recommendations seek to strengthen a resilient and circular value chain, while also promoting cooperation with academic institutions and research organizations to ensure that the digital and sustainable transition becomes a continuous, shared learning process across the region.

2.1.1 Policy Recommendations that Address Different Levels of Economy

Readiness

Given the significant variation in digital readiness among APEC member economies, a single, uniform set of measures for the entire region is neither feasible nor desirable. Instead, policies should be designed in the form of a tiered approach that allows each economy to choose a pathway consistent with its existing infrastructure base, human capital, and fiscal capacity. Survey results indicate that most economies are still at an early to intermediate stage of preparedness, with only a small number having implemented broad, strategic initiatives. Policy recommendations in this dimension therefore focus on differentiated policy packages, such as:

For economies at an early stage, the emphasis should be on laying the groundwork by supporting enterprises to begin using basic ERP/CRM systems, establishing systematic production data collection, and raising awareness of the importance of traceability.

For economies at an intermediate stage, the focus should be on upgrading toward supply chain monitoring systems that enable cross-organizational data integration, the use of IoT and cloud platforms, and real-time tracking of production, transportation, and environmental standards.

For highly prepared economies, the priority should be to develop and deploy advanced technologies—such as AI for demand forecasting, energy efficiency optimization, and big data analytics—to support the design of more flexible and sustainable supply chains.

2.1.2 Context-Appropriate Approaches to Promoting Technology Adoption

The key obstacle does not lie in an absolute lack of technology, but rather in the mismatch between available technologies and the actual needs of local manufacturers, as well as structural inequalities in digital infrastructure and the absence of clear regional standards for smart manufacturing. Evidence from APEC and ILO documents further indicates that SMEs have yet to adopt many critical technologies and that systematic policy support remains insufficient, resulting in the use of RFID, IoT, blockchain, and cloud systems being largely confined to major industry players.

Policy recommendations in this area therefore emphasize the design of support measures that enable technologies to reach factory level in forms that are appropriate to enterprise size and process complexity. Examples include promoting modular, low-cost ERP/traceability solutions that allow firms to start with basic functions (such as inventory, purchasing, and lot recording) and later expand to more advanced modules as their capabilities grow; supporting shared digital service platforms for SMEs to reduce individual system investment costs; and linking technologies to downstream market standards so that adopted solutions create genuine, long-term market opportunities rather than becoming merely an additional cost burden.

2.1.3 Policies that Facilitate Integration among Business, Government, and Academic Sectors

The digital transition of textile supply chains is a highly complex process that cannot be driven by any single group of actors in isolation. Survey results indicate that key enablers

for the adoption of advanced technologies such as AI include government support, collaboration with research institutions, and continuously improving infrastructures for sensors and automation. Policy recommendations in this dimension therefore aim to build a triple-helix ecosystem in which the private sector articulates real-world problems and needs, governments provide policy frameworks and incentives, and universities and research institutes generate knowledge and skilled personnel while co-developing prototype digital tools.

Illustrative measures include pilot projects that link model factories with universities to test ERP/IoT/AI systems under real operating conditions, with partial cost support from public agencies; the establishment of regional collaboration centers for sharing standard specifications, sample datasets, and best practices in supply chain monitoring; and mechanisms for engaging international brands and major buyers in co-defining data standards and digital requirements, so that producers in APEC economies can adjust in a targeted manner and gain access to higher-value markets.

2.2 Incentive Measures and Support Mechanisms for Technology Adoption

Investment constraints and skills gaps are the most significant obstacles to advancing digital strategies in textile supply chains. Nearly all respondents indicated that financial resources constitute a major constraint (over 96.00 percent), while shortages of personnel with adequate digital skills and a lack of well-coordinated policy support across sectors were also highlighted. Policy recommendations on incentive measures must therefore simultaneously address financial barriers, infrastructural requirements, and capacity development.

2.2.1 Recommendations on Tax Incentives, Grants, and Concessional Loans

Survey respondents clearly indicated that fiscal and financial instruments—such as subsidies, soft loans, dedicated funds, and tax measures—are essential tools for reducing upfront costs associated with investments in ERP, CRM, PLM, digital traceability systems, automation, and AI technologies, particularly for SMEs. Accordingly, it is recommended that tax deduction or tax credit schemes be introduced for investments in software and hardware related to supply chain monitoring and energy efficiency; that conditional funds or low-interest loan programs be established, linked to demonstrable improvements in production efficiency, energy reduction, or data transparency; and that matching-grant schemes be developed whereby governments co-finance a proportion of investment when enterprises adopt technologies aligned with regional standards and environmental objectives.

2.2.2 Support Mechanisms for Assisting SMEs in the Digital Transition

As SMEs are the group most affected by budget and skills constraints, yet at the same time constitute critical nodes in textile supply chains across the APEC region, there is a clear need for measures specifically tailored to this segment. Lessons from the case studies suggest that member economies can adopt approaches such as short-term training programs; the development of data templates and QR codes aligned with the EPCIS standards framework; and financial instruments such as digital vouchers or dedicated funds for digital equipment, combined with follow-up assessments 6–12 months after project completion to ensure that pilot technology adoption can be scaled up into effective business use.

At the same time, the evidence shows that many SMEs still lack the application of key technologies and are not benefiting from sufficiently systematic policy support, leading to a concentration of advanced technology use among large firms. Appropriate measures should therefore also include the establishment of digital advisory centers for SMEs, the development of shared platforms for accounting and production tracking, and the design of training curricula that are explicitly linked to the real operational challenges faced by factories in each locality.

2.2.3 The Role of Central and Local Governments in Building a Supportive Ecosystem

The prioritization of strategies clearly indicates that joint investments in shared digital infrastructure and the harmonization of standards and regulatory frameworks are viewed by respondents as among the most effective approaches for driving the digital transition. This underscores the critical role of central and local governments as enablers responsible for preparing the enabling environment rather than as direct implementers of projects on behalf of the private sector. In practical terms, governments can invest in high-speed internet infrastructure, public cloud systems, and data-exchange platforms that comply with international standards, thereby allowing private enterprises especially SMEs to access these resources at reasonable cost.

In addition, governments can design policies that are coordinated across economic, trade, industrial, environmental, and labor agencies to reduce regulatory overlap and conflict, and to support the establishment of clusters or smart textile innovation zones that integrate factories, technology providers, universities, and public institutions within the same geographic area.

2.2.4 Establishing Common Standards and Cross-Border Connectivity

The success of cross-regional supply chain monitoring depends fundamentally on

a shared data “language” through which all economies can communicate. The case studies indicate that defining a minimum common regional data set based on standards such as EPCIS/CBV and linking that data to the requirements of destination markets such as DPP policies and circular economy regulations can significantly facilitate smoother integration between domestic monitoring systems and customs or cross-border regulatory agencies. At the same time, survey findings reveal that difficulties in aligning cross-border regulations and standards constitute one of the major obstacles to digital transition.

Regional policies should therefore prioritize the establishment of long-term dialogue mechanisms under the APEC framework to jointly define and periodically review minimum common data standards, as well as to develop cross-border regulatory sandboxes for piloting new technologies such as blockchain and AI in supply chain monitoring. In addition, mechanisms for mutual recognition of certain types of certificates should be promoted to reduce duplication in verification processes and to lower international transaction costs.

2.2.5 Capacity Building and Knowledge Sharing

Beyond infrastructure and financial measures, survey results place very high importance on the development of human skills and capabilities. Strategies to expand access to digital skills training for stakeholders across the supply chain rank among the most critical priorities, and respondents’ policy proposals clearly emphasize regional training mechanisms on ERP/PLM/AI, digital management, and lean management.

It is therefore recommended that region-wide training programs both online and blended be developed specifically for the textile industry; that expert exchange schemes be promoted among member economies to facilitate the transfer of practical experience from successful factories; and that an accessible repository of case studies and practical guidelines be created for all economies. Such a repository would serve as a starting point for economies and enterprises seeking to design their own digital transformation plans.

2.3 Risk Management and Approaches to Mitigating Policy Impacts

Promoting the digital transition of textile supply chains within the APEC framework and the adoption of advanced technologies undoubtedly creates opportunities in terms of efficiency and competitiveness. However, it also inevitably generates policy risks across multiple dimensions—economic, social, labour-related, and data governance. If risk management mechanisms are not designed in parallel with promotional measures, the digital transition may exacerbate inequalities between economies, between large enterprises and SMEs, and between highly skilled workers

and traditional workers in the textile sector. The objective of risk management, therefore, is not to slow down the transition, but to ensure that it proceeds in a fairer and more structurally sustainable manner.

First, there is the risk associated with the digital divide between large enterprises and SMEs, as well as between economies with differing levels of digital infrastructure. This gap is likely to widen if support measures primarily target actors that are already well prepared. The findings clearly indicate that technological and skills gaps among SMEs constitute a major obstacle to cross-regional supply chain monitoring. It is thus essential to design policies that explicitly aim to narrow these gaps, both through targeted support for specific groups and through monitoring and evaluation frameworks that incorporate considerations of equity.

Second, there is the risk of adverse impacts on workers and communities. The introduction of automation and AI to replace certain types of work may displace low-skilled workers if there are no accompanying measures for reskilling and upskilling, or appropriate social protection systems. Policies should therefore link technology investment support to requirements for worker training and for factory-level social impact management plans.

Third, there are risks related to the protection of personal and commercially sensitive data. As supply chain monitoring systems increasingly interconnect data from multiple parties and across borders, data protection frameworks—such as the principles underlying the Global CBPR/PRP initiative—highlight the need for systematically designed mechanisms for obtaining consent, managing data-subject rights, and conducting anonymization. These are necessary to enable the use of data for policy analysis without infringing upon the rights of individuals and firms.

In summary, risk management and mitigation of policy impacts in the context of the digital transition of textile supply chains in the APEC region must connect three core dimensions: (1) reducing the digital divide and structural inequalities; (2) addressing impacts on workers and communities alongside skills upgrading; and (3) aligning regulatory frameworks across agencies and across member economies, so that the transition does not become an excessive burden on enterprises. At the same time, risk management frameworks should be flexible, subject to revision, and open to new evidence from empirical monitoring and evaluation, allowing each economy to adjust its policies in line with its level of readiness—ranging from the phase of upgrading toward real-time monitoring using IoT and cloud systems, to the stage at which AI and

big data analytics are employed to design future supply chains that are more sustainable and inclusive.

2.4 Policy Implementation Plan and Regional Cooperation

To translate the above policy recommendations into concrete action, it is necessary to formulate an implementation plan that links local and regional levels, considering each economy’s level of readiness and budgetary constraints.

Table 3: Phased Implementation of Policy Measures in the Short, Medium, and Long Term

Implementation Steps	Details
Short Term (1–3 years): Laying the Foundation	<ul style="list-style-type: none"> Formulate a domestic digital roadmap for the textile industry that is aligned with the APEC cooperation framework. Launch pilot projects in selected factories and supply chains with sufficient readiness to test ERP/IoT/traceability technologies and generate concrete case studies. Design and initiate financial and fiscal measures to support technology investment by SMEs.
Medium Term (3–7 years): Scaling Up and Harmonizing Standards	<ul style="list-style-type: none"> Expand the use of digital platforms and common data standards to a wider range of supply chains. Integrate production, transport, and environmental data into local and regional monitoring systems. Accelerate digital skills development through training programs and enhanced collaboration between universities and the private sector.
Long Term (more than 7 years): Building a Fully Integrated Digital Supply Chain Ecosystem	In the long term, the objective is to integrate advanced technologies—such as AI, big data analytics, and advanced automation into global environmental and social standards, using data accumulated in earlier phases as a foundation for designing increasingly precise policies. The sequencing into short-, medium-, and long-term phases should remain flexible and be adjusted to the readiness levels of each economy, given that analysis of the study survey conducted under APEC Project PPSTI 113 2024A indicates that most are still at an early to intermediate stage of preparation ^[1] .

Note. [1] Source: Analysis of the "Cross-Regional Supply Chain Monitoring Survey" conducted as part of APEC Project PPSTI 113 2024A: "2025 APEC International Seminar on the Application of Smart Technology to Textile Industry" (November 2025).

3. Selected Success Cases for Cross-Regional Supply Chain Monitoring

3.1 Case Selection Criteria and Methodology

The selection of case studies in this research aims to identify examples that comprehensively reflect the successful monitoring of cross-regional textile supply chains, across dimensions of geography, industry, technology, and policy context. This is intended to enable effective comparative analysis and the synthesis of policy-relevant lessons. The criteria for case selection therefore follow a stepwise, multi-dimensional

approach, ensuring that the selected cases are sufficiently diverse while still comparable within a common research framework.

The case selection approach will be implemented across six dimensions:

Geographical dimension: Priority is given to economies or economies that play a prominent role in the international textile industry within key APEC regions such as East Asia, Southeast Asia, North America, and Oceania to enable clear comparative analysis of structural and policy contexts across regions.

Industrial dimension: The analysis covers the upstream, midstream, and downstream segments of the textile supply chain. The upstream segment focuses on areas with significant production bases for key raw materials, such as natural and synthetic fibers. The midstream segment considers locations that are central to spinning, weaving, dyeing and printing, and garment manufacturing processes. The downstream segment concentrates on major consumer markets and large retail operators. This framework makes it possible to trace product flows from the origin of raw materials to the final consumer and serves as a criterion for assessing whether monitoring systems operate only at the factory level or extend across the entire supply chain.

Technological and tools dimension: Economies are selected on the basis of their use or piloting of modern technologies related to traceability and monitoring, such as digital platforms, blockchain technologies, IoT systems, smart labels like RFID, or QR code linked to databases. This enables an assessment of both the effectiveness and the technical limitations of these solutions in parallel.

Legal and standards dimension: This dimension considers the alignment with relevant legal frameworks and international standards, such as the European Union's regulations on digital product passports, GS1 standards, and the International labor Organization's requirements on labor conditions and human rights.

Sustainability dimension: This dimension places emphasis on social and environmental aspects, such as reducing greenhouse gas emissions, improving waste management, and ensuring transparent verification of raw material origins.

Production and trade dimension: This dimension considers economies or regions that serve as major bases for textile production or export, so that the selected case studies can concretely reflect the complexity of cross-border supply chains and the structural challenges involved.

Based on the case selection criteria outlined in the preceding section, this study identifies an interregional textile supply chain that spans upstream, midstream, and downstream stages, focusing on **Australia; People’s Republic of China; United States; and Viet Nam**. These economies play different roles within the structure of the textile industry, yet each constitutes a critical node in global production and trade systems. They have also invested in the development of supply chain monitoring and traceability systems in ways that meaningfully reflect their respective economic, social, and policy contexts.

3.2 Case Study

Table 4: Summary of the Four Economy Case Studies

Segment in the Supply Chain	Economy	Role	Examples of Technologies / Platforms	Success Factors	Empirical Outcomes	Key Lessons Learned	Cross-Regional Linkages
Upstream	Australia	Producer of high-quality textile raw materials, particularly cotton and merino wool, for export to major processing economies.	<ul style="list-style-type: none"> QR code and blockchain-based traceability systems for verification of product provenance WoolQ platform developed by Australian Wool Innovation (AWI) for recording and tracking data from farms to buyers Use of QR codes on packaging to enable buyers to verify farm-level information and production standards 	<ul style="list-style-type: none"> Strong reputation and brand equity associated with merino wool Institutional support from AWI and standard setting / certification bodies Consumer demand that emphasizes product quality and sustainability 	<ul style="list-style-type: none"> Increased value-added and successful positioning as premium-brand products Enhanced consumer confidence through access to digital product information Reduction in counterfeiting and mislabeling incidents 	Generating value-added from raw materials requires integrating traceability information with branding strategies and globally recognized standards.	Exports raw materials to People's Republic of China; and Viet Nam.
Midstream	People's Republic of China	Major hub for large-scale textile processing and manufacturing, encompassing spinning, weaving, dyeing, and garment production.	<ul style="list-style-type: none"> Blockchain systems for supply chain data management IoT-based quality control Better Cotton Initiative (BCI) and AntChain blockchain (Ant Group) for cotton fiber traceability, enabling tracking from cotton cultivation to weaving mills, with real-time quality data captured via IoT sensors 	<ul style="list-style-type: none"> Very large production capacity Strong public and private investment in IoT and blockchain technologies Enforcement of quality and export standards 	<ul style="list-style-type: none"> Improved efficiency in quality management Reduced losses arising from defective products Increased transparency in production and export processes 	Investment in technology and data management is critical for maintaining leadership in textile manufacturing.	Imports cotton from Australia and exports textile products to the United States.

Segment in the Supply Chain	Economy	Role	Examples of Technologies / Platforms	Success Factors	Empirical Outcomes	Key Lessons Learned	Cross-Regional Linkages
Downstream	United States	Major consumer market and centre for the development of traceability and sustainability standards, utilising big data, AI, and blockchain to monitor supply chains.	<ul style="list-style-type: none"> AI-driven Demand Forecasting Blockchain Traceability Sustainable Apparel Coalition's Higg Index and IBM Food Trust Blockchain 	<ul style="list-style-type: none"> Global sustainability standards set and driven by major brands Substantial investment in advanced technologies (AI and blockchain) High consumer concern for ethical fashion and transparency 	<ul style="list-style-type: none"> Consumers have clearer information to support purchasing decisions Reduced risks of supply chain disruptions through big data analytics Upgrading of international environmental and human rights standards 	The roles of consumers and retailers can shape the direction of global standards and exert pressure on suppliers worldwide to adapt and comply.	Imports finished textile and apparel products from People's Republic of China and Viet Nam.
	Viet Nam	Export-oriented garment manufacturing base, primarily operating as an Original Equipment Manufacturer (OEM) for global brands, and increasingly investing in digital systems for order and production tracking.	<ul style="list-style-type: none"> RFID and cloud-based supply chain management systems Platforms such as Infor Nexus and Lectra Fashion PLM for integrating production and logistics data Traceability systems to verify compliance with labor and environmental standards 	<ul style="list-style-type: none"> Market pressure from the United States and Europe, which require traceability Collaboration with international brands and adoption of relatively low-cost digital technologies Adaptive responses by factories to enhance their competitiveness 	<ul style="list-style-type: none"> Enhanced competitiveness in global markets Improved access to high-standard markets such as the United States and the European Union Strengthening of Viet Nam's image as a transparent and responsible manufacturing economy 	Collaboration with foreign partners is a key driver for upgrading production standards and supply chain monitoring systems.	Imports fabrics from People's Republic of China and exports garments to the United States.

3.3 Comparative Analysis of Success Cases

3.3.1 Comparing the Commonalities and Differences of the Case Studies

The comparative analysis of the four economy case studies highlights both common patterns in the development of cross-regional supply chain monitoring systems and strategic differences that reflect the specific contexts of each economy.

On the side of common patterns, all four cases are anchored in international standards to ensure interoperability of their systems. Examples include the use of GS1 EPCIS/CBV standards in combination with two-dimensional codes (QR codes) and GTINs to link data from raw material intake, production, and transportation through to distribution. This enables organizations and economies to exchange, verify, and trace information in a consistent manner. In addition, all cases feature the development of multi-enterprise network systems that support B2B operations by integrating purchase orders, transport documents, and financial data in real time, thereby reducing costs, enhancing end-to-end supply chain visibility, and improving overall operational efficiency. The use of RFID as a primary tool for item-level identification and tracking is also evident across the cases; in the United States, this has evolved into an industry-wide requirement in the retail sector, alongside preparations of data systems to support the Digital Product Passport (DPP) concept, which specifies product data standards across the entire life cycle.

In terms of key differences, Australia places particular emphasis on source accuracy and chain of custody, especially for agricultural products such as wool, through the eBale system, which integrates RFID and QR codes to link data into an industry-level tracking hub. People's Republic of China; and Viet Nam, by contrast, focus on enhancing operational efficiency and production quality by combining RFID with manufacturing information systems, computer vision, and IoT to control production processes, track work-in-progress, and conduct in-factory quality inspection. The United States, meanwhile, prioritizes omnichannel capabilities and inventory accuracy in the retail system by mandating RFID at the industry level and deploying two-dimensional barcodes to provide detailed product information at the point of sale.

3.3.2 Key Components of Monitoring Systems that are Critical to Success in Each Context

This section focuses on examining the linkages between identification and tracking technologies (such as RFID, two-dimensional codes, and shared data

platforms) and the policy environment, industrial structure, and readiness of stakeholders within each supply chain. It further synthesizes which components constitute key enabling conditions that must be considered when designing and implementing monitoring systems in other contexts within the APEC region.

Table 5: Key Components of Monitoring Systems Critical to Success in Each Context

Economy	Supply Chain Monitoring Systems Critical to Success
Australia	The eBale system functions as a key infrastructure for wool traceability by utilizing wool bales equipped with both unique QR codes and RFID microchips to record information on origin, market-relevant attributes, and other associated data. This information can be captured and updated from the farm level via the WoolClip application, which is used for classing and registering wool data, and is subsequently linked to the sector-wide central platform, the Australian Wool Traceability Hub, which covers the majority of stakeholders in this industry. As a result, a shared database is established that enables the systematic verification of product origin and quality at an industry-wide level.
People’s Republic of China	This illustrates that the success of monitoring systems does not depend solely on technology but also requires organizational and managerial factors. The introduction of garment manufacturing information systems embedded with RFID technology into sewing factories makes it possible to track the movement of workpieces throughout the production line using RFID tags and readers. The study identifies eight critical success factors: appropriate selection of technology vendors, organizational motivation, careful weighing of costs and benefits, support from top management, user participation, the degree of progress monitoring, staff capabilities and training, and the alignment of policies, structures, and processes with the new system. Together, these elements ensure that the implementation of the monitoring system is not merely a “technology project,” but becomes an integral part of organizational transformation toward more efficient production processes.
United States	The introduction of RFID mandate policies by large retailers, such as Walmart, constitutes an institutional driver that accelerates the upgrading of monitoring systems in retail supply chains. Each garment carries a unique identifier encoded in a chip embedded within the electronic article surveillance system, enabling item-level identification, accurate in-store inventory management, and more efficient distribution to multiple outlets. These policies therefore act as a catalyst compelling partners throughout the supply chain to invest in compatible technologies and processes, thereby raising tracking standards across the industry as a whole.
Viet Nam	A key factor underpinning success lies in the investment structure and the enhanced production capacity resulting from substantial foreign direct investment (FDI) in the textile and garment sector. The presence of modern factories owned by major investors from within and outside the Asian region has enabled Viet Nam to rapidly absorb advanced production technologies, modern supply chain management systems, and production and quality monitoring systems. According to surveys by the United States Fashion Industry Association, Viet Nam receives consistently strong ratings across all dimensions of sourcing performance, which has positioned the economy as a major manufacturing base for global brands and created powerful commercial incentives to invest in supply chain monitoring systems at a visible and significant scale.

3.4 Key Takeaways and Lessons Learned

3.4.1 Best Practices

First, the case studies underscore the importance of using common standards for

supply chain event data, particularly the application of GS1 EPCIS/CBV 2.0 as a central framework for recording and exchanging event information across organizations and across borders. Its ability to support modern data formats such as JSON/REST, integrate data from sensors and IoT devices, and link with GS1 Digital Link helps reduce system integration costs, lower dependence on any single service provider, and enhance the reliability of digital evidence used for traceability and joint supply chain governance.

Second, downstream standards and requirements, especially those set by large retailers, act as a major driving force for upgrading entire networks. For example, the requirement for item-level RFID tagging in apparel and its extension to other product categories during 2022–2024 has compelled manufacturers and suppliers in multiple regions to accelerate their adjustments in tagging practices, stock management, and data quality improvement. The use of such downstream market mechanisms has thus proven to be an effective practice for concretely driving investment in technologies and data standards across the entire supply chain.

Third, the establishment of product-specific traceability platforms and industry-level data hubs such as the eBale system in the wool industry, which combines RFID and QR codes with the Australian Wool Traceability Hub (AWTH) provides a tangible example of sectoral data infrastructure designed to support traceability from farm-level origins through to primary processing. Such systems not only build confidence in the transparency and accuracy of origin data but also strengthen the capacity to respond to biosecurity threats and data requirements from downstream markets. The experience of textile-fiber traceability platforms, which began as pilot projects between raw-material producers and major fashion brands and subsequently scaled up to the industry level, further demonstrates that platforms tailored to specific product categories and key stakeholders can effectively close information gaps along the supply chain.

Fourth, the use of cloud-based supply chain management (SCM) networks to connect manufacturers, logistics providers, and brands across regions enables near-real-time visibility over inventory status, shipping documents, and order progress. Such systems play a critical role in reducing delays, lowering operational costs, and improving preparedness to handle disruptions, such as transport delays or rerouting of goods across regions.

3.4.2 Lessons Applicable to Other APEC Member Economies

Based on the comparative synthesis of lessons learned, six key dimensions can be identified for transferring these insights to the contexts of other APEC member economies.

Table 6: Lessons Applicable to Other APEC Member Economies

Lesson	Examples of Adaptation by Other APEC Member Economies and Key Factors to Consider
Dimension 1: Establishing a Minimum Common Regional Data Set	This serves as a foundation for developing pilot projects, particularly in the textile industry, where cross-regional linkages are highly intensive. Defining event types, product and lot identifiers, linkages to certifications, and other data requirements within an EPCIS/CBV-based framework that is aligned with the requirements of destination economies—such as Digital Product Passport (DPP) policies or circular economy regulations—helps ensure that domestic monitoring systems “speak the same language.” It also facilitates smoother connectivity with customs authorities and cross-border regulatory agencies.
Dimension 2: Designing the Standards Architecture before the Platform	Emphasis should be placed on open standards and on minimizing dependence on any single service provider (vendor lock-in). Member economies should establish sandboxes or conformance testing systems for platform providers and their own system developers to ensure that different systems can genuinely exchange data. The acceptance of a common set of rules by governments, the private sector, and technology providers thus constitutes a critical prerequisite for building network-based monitoring systems.
Dimension 3: Establishing Industry-Level Data Hubs and Shared Data Governance	Member economies can adapt the concept of industrial hubs locally to the regional level for example, by creating cotton or polyester data hubs jointly financed and co-governed by the private sector under open standards, with clear rules on data sharing and fair competition. Such frameworks help build trust among both large and small actors, encourage broad participation, and reduce information asymmetries among firms operating within the same supply chain.
Dimension 4: Positioning Downstream Actors as Key Drivers for Upgrading Supply Chain Monitoring Systems	Allowing downstream retailers and brands to establish tagging and data requirements (for example, RFID tag standards or data aligned with international norms) as conditions for accepting products enables end-market specifications to cascade back through the entire supply chain. This approach accelerates the adoption of new technologies by manufacturers, suppliers, and logistics providers. In practice, such measures can be designed as a “phased RFID mandate,” beginning with product categories that are relatively well prepared—such as high-value items or goods that require detailed tracking—in order to first evaluate impacts on efficiency, data accuracy, and operational processes. Once clear lessons have been drawn, implementation can be gradually extended to other product groups. However, the design of such measures must carefully take into account the readiness levels of suppliers at different tiers and the overall cost structure of the supply chain. Without mechanisms to alleviate initial investment burdens or provide appropriate support, smaller firms may be unable to comply with the requirements, thereby exacerbating adaptation gaps and competitive inequality between large and small actors within the supply chain.
Dimension 5: Data Protection	Lessons from the implementation of the Global CBPR/PRP as a framework for certifying cross-border data transfers indicate that supply chain monitoring initiatives involving personal data or location data must be accompanied by robust governance mechanisms for consent management, data subject rights, and systematic anonymization. Such safeguards are essential to enable the use of data for statistical purposes and policy analysis

Lesson	Examples of Adaptation by Other APEC Member Economies and Key Factors to Consider
	without violating internationally recognized principles of personal data protection.
Dimension 6: Strengthening the Digital Capacity of SMEs	Member economies can adopt approaches such as short training programs, the development of low-cost tools (for example, the use of QR codes and EPCIS data templates), and financial measures such as digital vouchers or funds for digital equipment. These should be combined with follow-up plans 6–12 months after participation to ensure that small enterprises are able to move from pilot adoption to effective, business-level use in practice.

4. Results and Analysis of Cross-Regional Supply Chain Monitoring Survey

4.1 Objectives and Methodology

The Cross-Regional Supply Chain Monitoring Survey aims to provide a comprehensive assessment of the current landscape and future directions of smart manufacturing in the textile industry across APEC economies. The findings will inform the formulation of evidence-based, actionable policy and industrial recommendations, thereby fostering more resilient, sustainable, and technologically advanced textile manufacturing systems throughout the APEC region.

Data was collected through an online survey administered as part of a broader APEC initiative on smart manufacturing and digital transformation into textile supply chains. The questionnaire was disseminated via project partners and relevant industry networks to reach stakeholders across different segments of the textile value chain, including manufacturers, technology providers, and supporting organizations. Responses were recorded electronically and exported for analysis. Quantitative items, including Likert-scale, multiple-choice, and ranking questions, were examined using descriptive statistics, such as frequencies, percentages, and average ranking scores, to identify prevailing patterns and comparative priorities. Open-ended questions were analyzed using a thematic analysis approach, whereby responses were systematically coded and grouped into recurring themes related to technology needs, barriers, and policy recommendations. The combination of descriptive statistics and qualitative thematic analysis enabled a nuanced interpretation of the data, linking numerical trends with respondents’ underlying rationales and contextual explanations.

4.2 Survey Results

4.2.1 Smart Manufacturing Readiness and Technology Adoption in APEC: Regional Needs and Gaps

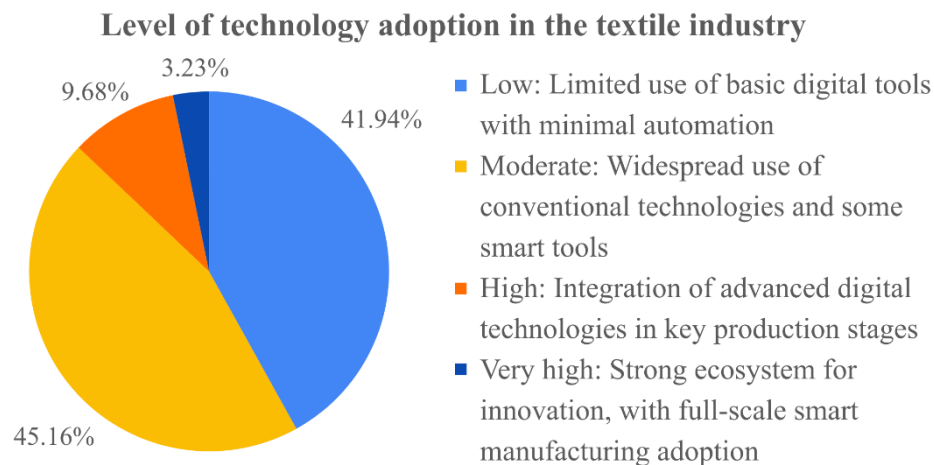


Figure 1: Level of technology adoption in the textile industry

Respondents generally perceived the level of technology adoption in the textile industry across their region's economies to be in the low-to-moderate range. A plurality of participants (45.16%, 14 out of 31) assessed adoption as moderate, characterized by widespread use of conventional technologies and some smart tools. A further 41.94% (13 respondents) rated the level as low, indicating limited use of basic digital tools with minimal automation. Only a small minority reported more advanced conditions: 9.68% (3 respondents) perceived a high level of adoption, with integration of advanced digital technologies in key production stages, while just 3.23% (1 respondent) viewed the ecosystem as very high, with full-scale smart manufacturing adoption. No respondents selected very low. Overall, the findings suggest that, at a regional level, the textile sector is still in a transitional phase, moving from conventional technologies toward more digitally enabled and smart manufacturing systems, with only a few economies approaching a fully mature smart manufacturing ecosystem.

Current state of technology adoption in the textile industry

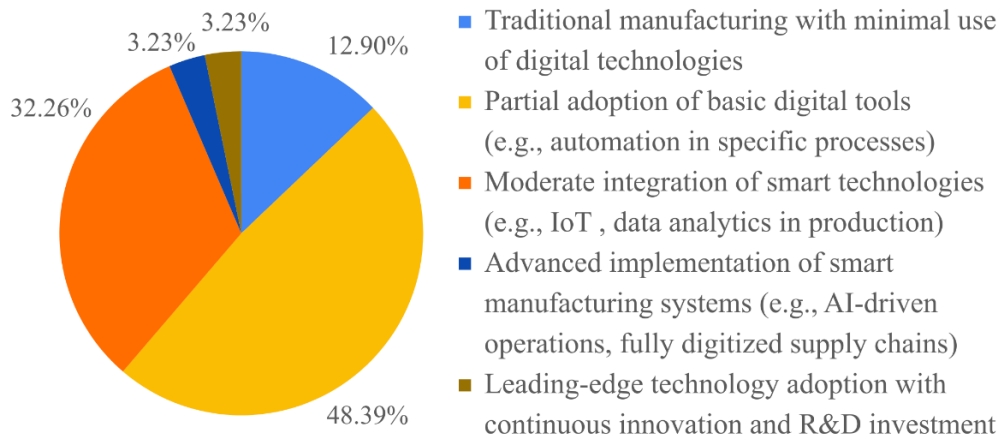
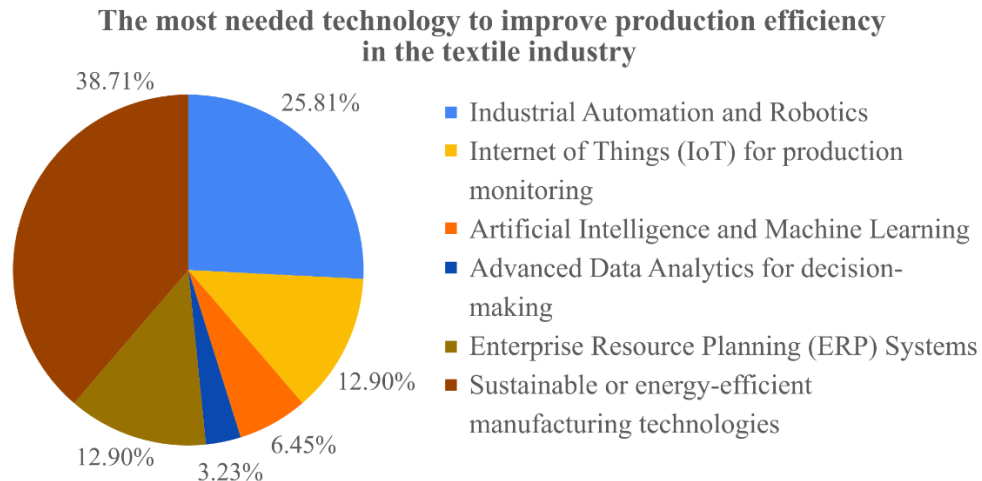


Figure 2: Current state of technology adoption in the textile industry

When asked to assess the state of technology adoption in their own economy or organization, especially regarding production efficiency and smart manufacturing, respondents reported a somewhat more nuanced distribution. Nearly half (48.39%, 15 respondents) indicated *partial adoption of basic digital tools*, such as automation in specific processes, reflecting incremental rather than systemic digitalization. Another 32.26% (10 respondents) described a *moderate integration of smart technologies* (e.g., IoT and data analytics in production), indicating that a substantial subset of organizations has begun to embed smart systems beyond isolated tools. At the lower end, 12.90% (4 respondents) reported *traditional manufacturing with minimal use of digital technologies*, underscoring that legacy production models remain present. Only 3.23% (1 respondent) characterized their context as having *advanced implementation* of smart manufacturing systems, and another 3.23% (1 respondent) as *leading-edge*, with continuous innovation and R&D. Taken together, these results suggest a heterogeneous landscape, with most organizations situated in an early to intermediate stage of digital transformation, and only a small number acting as advanced frontrunners.



**Figure 3: The most needed technology to improve production efficiency
in the textile industry**

Regarding the technology most needed to improve production efficiency in the textile industry, respondents prioritized sustainability-oriented solutions alongside automation. The most frequently selected option was sustainable or energy-efficient manufacturing technologies, chosen by 38.71% (12 respondents), indicating strong concern for energy use, environmental performance, and cost efficiency as integral to competitiveness and resilience. Industrial automation and robotics ranked second, with 25.81% (8 respondents), highlighting continued demand for higher levels of automation in production processes. Other technologies received more modest support: Internet of Things (IoT) for production monitoring and Enterprise Resource Planning (ERP) systems were each selected by 12.90% (4 respondents), while Artificial Intelligence and Machine Learning and Advanced Data Analytics for decision-making were selected by 6.45% (2 respondents) and 3.23% (1 respondent), respectively.

Barrier to adopting smart manufacturing technologies in the textile industry

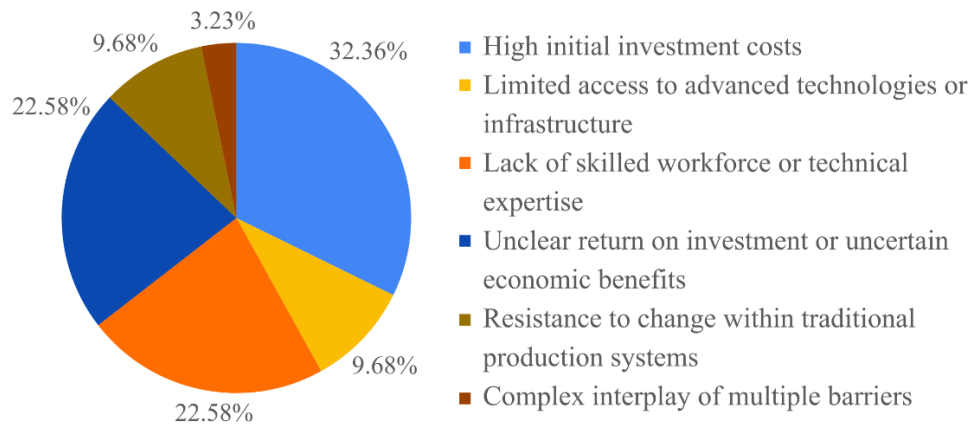


Figure 4: Barrier to adopting smart manufacturing technologies in the textile industry

The perceived barriers to adopting smart manufacturing technologies are dominated by financial and capability-related constraints. The most frequently cited primary barrier was high initial investment costs, selected by 32.26% (10 respondents), indicating that capital expenditure remains a key obstacle to deployment of advanced technologies. Two other factors were equally salient: lack of skilled workforce or technical expertise and unclear return on investment or uncertain economic benefits were each selected by 22.58% (7 respondents). Limited access to advanced technologies or infrastructure and resistance to change within traditional production systems were chosen by 9.68% (3 respondents), indicating that structural and cultural barriers are also relevant but less frequently ranked as the single most significant obstacle. Additionally, one respondent (3.23%) explicitly pointed to a complex interplay of multiple barriers, combining high investment costs, resistance to change, and limited collaboration among stakeholders. This multi-factor perspective underscores that, in practice, barriers often interact rather than appear in isolation.

Regional challenges to adopting smart manufacturing in the textile industry

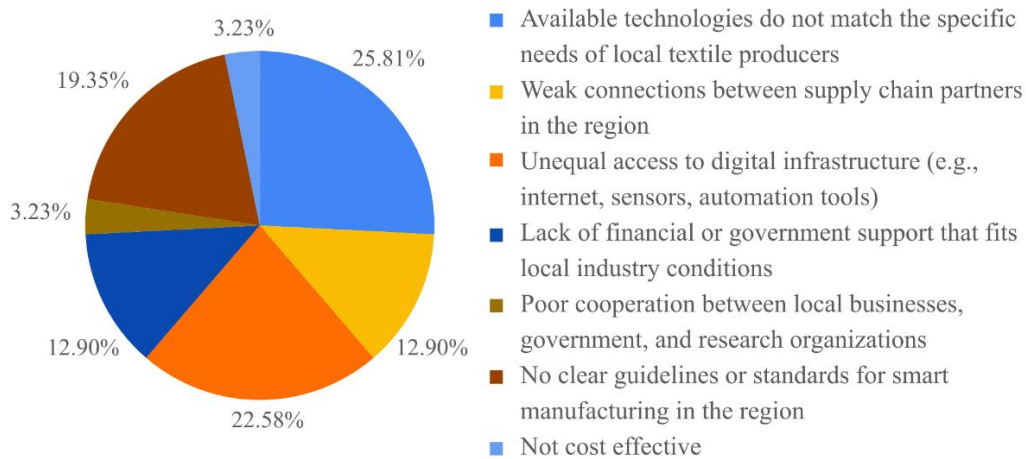


Figure 5: Regional challenges to adopting smart manufacturing in the textile industry

The most frequently cited challenge was that available technologies do not match the specific needs of local textile producers (25.81%, 8 out of 31 respondents), suggesting a significant gap between generic technological solutions and the practical requirements of local production systems. This was followed by unequal access to digital infrastructures such as internet connectivity, sensors, and automation tools reported by 22.58% (7 respondents), indicating that disparities in basic digital readiness remain a major obstacle to widespread technology uptake. A further 19.35% (6 respondents) pointed to the absence of clear guidelines or standards for smart manufacturing in the region, underscoring the importance of policy and regulatory frameworks in shaping coherent adoption pathways. Two challenges were each selected by 12.90% (4 respondents): weak connections between supply chain partners in the region and lack of financial or government support that fits local industry conditions, highlighting how fragmented collaboration and misaligned support mechanisms can hinder coordinated transformation efforts. Less frequently cited, but still noteworthy, were poor cooperation between local businesses, government, and research organizations and the perception that smart manufacturing is not cost effective, each identified by 3.23% (1 respondent).

4.2.2 Perspectives on Digital Transformation and Strategic Priorities for Enhancing Textile Supply Chain Efficiency in APEC Economies

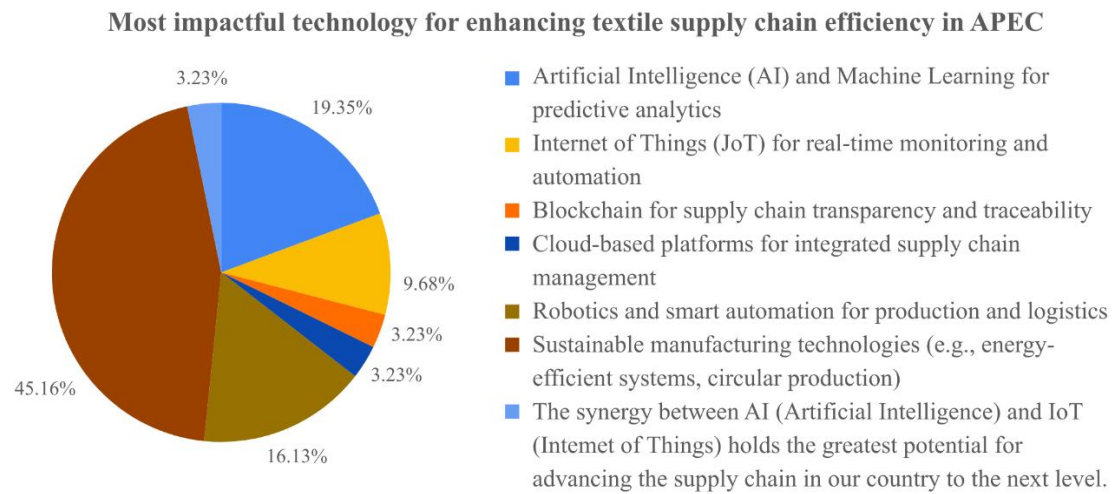


Figure 6: Most impactful technology for enhancing textile supply chain efficiency in APEC

When considering which technology holds the greatest potential for enhancing textile supply chain efficiency across APEC economies, respondents again prioritized sustainability-oriented solutions, but with notable support for AI-based tools and robotics. Sustainable manufacturing technologies (e.g., energy-efficient systems and circular production) were selected by 45.16% (14 respondents), making this the dominant choice and underscoring the view that environmental and resource efficiency are central to supply chain performance. Artificial Intelligence and Machine Learning for predictive analytics were chosen by 19.35% (6 respondents), reflecting recognition of the role of data-driven forecasting and optimization. Robotics and smart automation for production and logistics followed with 16.13% (5 respondents), indicating that many respondents consider physical automation across production and logistics as a key driver of efficiency. Other technologies were less frequently identified as the single most impactful: Internet of Things (IoT) for real-time monitoring and automation (9.68%, 3 respondents), Blockchain for transparency and traceability (3.23%, 1 respondent), and cloud-based platforms for integrated supply chain management (3.23%, 1 respondent). Additionally, one respondent (3.23%) explicitly emphasized the synergy between AI and IoT as the configuration with the greatest transformative potential, suggesting awareness that combined digital solutions may yield more than the sum of their parts.

Table 7: AI applications most relevant and impactful for the textile supply chain.

Detail	Score	Rank
1. Demand Forecasting – AI analyzes market trends, customer reviews, and social data to predict demand more accurately	58.00	1
2. Automated Material Handling – Robotic systems with AI assist in yarn loading and equipment setup to reduce labor errors and improve efficiency.	30.00	3
3. AI-based Textile Digitization – High-resolution imaging and metadata create realistic digital fabrics for faster design and sampling.	13.00	6
4. 3D Cloth Simulation – AI simulates fabric drape and behavior for virtual prototyping and design accuracy.	9.00	8
5. AI-Driven Quality Control – Computer vision detects defects (e.g., weave flaws, color mismatch) in real-time during production.	18.00	4
6. Energy Optimization – AI tracks and optimizes energy usage throughout the manufacturing process.	31.00	2
7. Predictive Maintenance – AI uses sensor data (vibration, tension) to forecast machine failures and minimize downtime.	16.00	5

Respondents were asked to identify up to three AI-related applications that are most relevant and impactful for enhancing the textile supply chain; the results are summarized via weighted scores and ranks. Demand forecasting, where AI analyzes market trends, customer reviews, and social data to improve demand prediction, received the highest score (58 points) and ranked first, indicating it is regarded as the most critical AI application in this context. Energy optimization, which uses AI to monitor and improve energy use across manufacturing processes, was ranked second with 31 points, highlighting concern for energy efficiency and cost reduction. Automated material handling, involving AI-enabled robotics for yarn loading and equipment setup, ranked third (30 points), suggesting that AI-driven automation in shop-floor operations is also viewed as highly impactful. Mid-ranked applications included AI-driven quality control (18 points, rank 4) and predictive maintenance (16 points, rank 5), both of which aim to enhance reliability and consistency in production. Lower scores were assigned to AI-based textile digitization (13 points, rank 6) and 3D cloth simulation (9 points, rank 8), which, while recognized, appear less central than core operational applications.

For the main challenges and enablers of adopting AI-related applications in the textile supply chain, respondents mentioned the following:

- Limited AI knowledge and skills, including weak understanding of benefits, ROI, and practical use cases, and a shortage of specialists to prepare high-quality data.
- Weak digital and data infrastructure: fragmented or non-integrated systems, insufficient IT equipment, legacy machines, poor ERP, and a lack of reliable data for training algorithms.
- High upfront and maintenance costs, with uncertain cost–benefit outcomes, making AI feel “out of reach” for many MSMEs.

- Concerns about algorithm accuracy, data consistency, and transparency, which reduce trust in AI-based decisions.
- Cultural and organizational inertia in traditional textile settings, where moving from manual to automated decision-making is difficult amid low competitiveness and an uncertain future.
- Targeted training and education in AI and data analytics to close skills gaps and build internal capabilities.
- Existing IoT sensor infrastructure and ongoing automation investments provide a technical foundation for AI applications.
- External pressure from brands, customers, and regulations on digitalization, sustainability, and energy optimization, creating strong incentives to adopt AI.
- Government subsidies, policy support, collaboration with research institutions, and cloud-based AI platforms that can reduce entry barriers.
- Strong financial management, a skilled workforce, stable raw materials, and overall supply chain readiness that support successful AI integration.

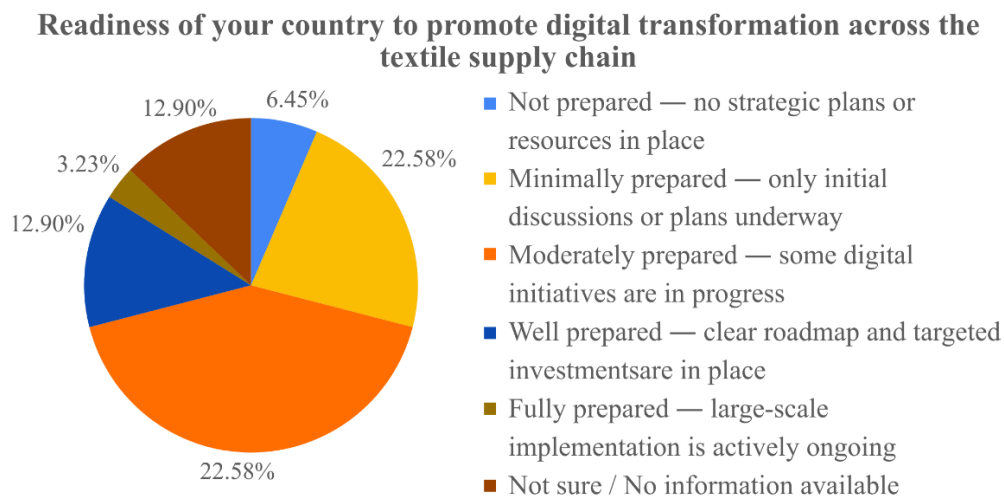


Figure 7: Readiness of your economy to promote digital transformation across the textile supply chain

Respondents’ perceptions of their economy’s readiness to promote digital transformation across the textile supply chain, in terms of both technology and institutional support, indicate a predominantly intermediate state. A plurality of respondents (41.94%, 13 individuals) rated their economy as moderately prepared, meaning that some digital initiatives are already in progress. Additionally, 22.58% (7 respondents) considered their economies minimally prepared, with only initial discussions or plans underway, and 6.45% (2 respondents) saw their contexts as not prepared, with no strategic plans or resources in place. On the more advanced side of the spectrum, 12.90% (4 respondents) described their economies as well prepared, having a clear roadmap and targeted investments, while just 3.23% (1 respondent)

perceived full preparedness with large-scale implementation actively ongoing. A further 12.90% (4 respondents) indicated that they were not sure or had no information available.

Table 8: The top three strategies are most effective in driving digital transformation in the textile supply chain among APEC member economies

Detail	Score	Rank
Investing in shared digital infrastructure across APEC economies	51.00	1
Harmonizing data standards and regulatory frameworks region-wide	48.00	2
Facilitating cross-economy knowledge exchange and best practice sharing	32.00	4
Expanding access to digital skills training for supply chain actors	35.00	3
Offering financial and policy incentives for technology adoption	20.00	5

In ranking strategies to drive digital transformation in APEC textile supply chains, respondents again prioritized structural and systemic interventions. Based on weighted scores, investing in shared digital infrastructure across APEC economies emerged as the most important strategy (51 points, rank 1), indicating strong support for regionally coordinated infrastructure development as a foundation for digital transformation. Harmonizing data standards and regulatory frameworks region-wide followed closely (48 points, rank 2), underscoring the perceived need for interoperability and regulatory coherence to facilitate cross-border operations and data flows. The third-ranked strategy was expanding access to digital skills training for supply chain actors (35 points, rank 3), highlighting recognition that human capital is a critical enabler of adoption of technology. Other strategies, while still valued, received lower scores: facilitating cross-economy knowledge exchange and best practice sharing (32 points, rank 4) and offering financial and policy incentives for adoption of technology (20 points, rank 5).

Key barriers to implementing digital transformation strategies in the textile supply chain

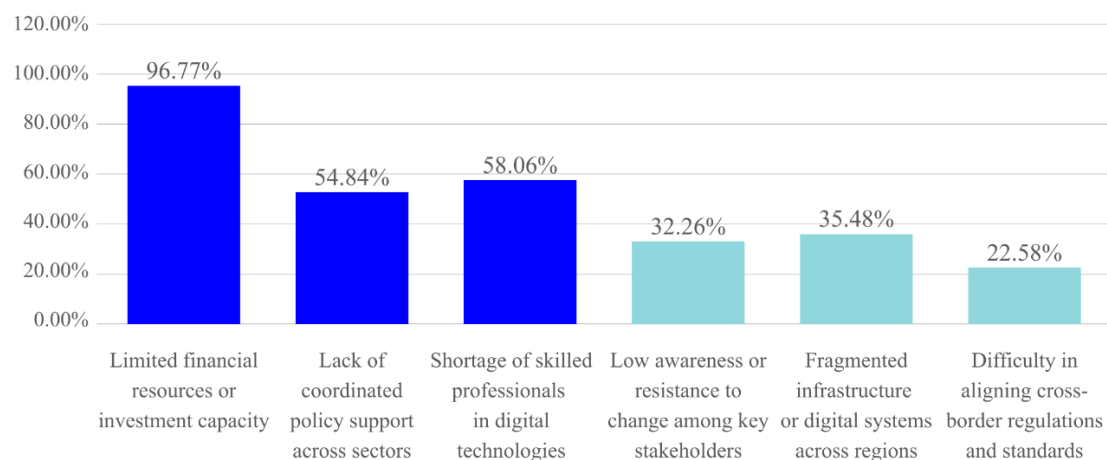


Figure 8: Key barriers to implementing digital transformation strategies in the textile supply chain

Respondents identified multiple, overlapping barriers to implementing the above strategies, reflecting the multi-dimensional nature of digital transformation. The most prominent constraint was limited financial resources or investment capacity, cited by 96.77% of respondents (30 out of 31), indicating that even when strategic priorities are clear, funding remains a critical bottleneck. A shortage of skilled professionals in digital technologies was reported by 58.06% (18 respondents), while lack of coordinated policy support across sectors was mentioned by 54.84% (17 respondents), suggesting that human capital and cross-sector governance are major systemic challenges. Other frequently cited issues included fragmented infrastructure or digital systems across regions (35.48%, 11 respondents) and low awareness or resistance to change among key stakeholders (32.26%, 10 respondents). Finally, 22.58% (7 respondents) pointed to difficulty in aligning cross-border regulations and standards, which is particularly salient in a multi-economic context such as APEC.

Respondents provide policy recommendations to promote digital transformation in the textile supply chain among APEC member economies, based on their experience and domestic context, as follows:

- Financial incentives for SMEs : Provide subsidies, soft loans, grants, and tax incentives to lower upfront costs of ERP, CRM, PLM, traceability, automation, and AI adoption.
- Capacity building and talent development : Establish region-wide training on ERP/PLM/AI, digital governance, lean management, and sustainability, focusing on technical experts who understand both digital tools and textile processes, and leaders who can drive change.
- Common standards and interoperable platforms : Harmonize data standards and develop interoperable digital platforms for traceability and supply chain management, in collaboration with international brands and guided by a clear sector-wide digital transformation roadmap.
- Support for SMEs and regional collaboration : Implement targeted SME digital-capacity programs, government-funded technical support, and public–private partnerships linking firms, research institutions, and governments to co-develop scalable solutions and reduce the digital divide while advancing sustainability goals.

5. Seminar Outcomes and Insights

The 2025 International Seminar on the Application of Smart Technology to the Textile Industry was conducted on 12–13 November 2025, with the purpose of strengthening shared understanding and practical awareness of smart manufacturing and digital transformation in textile supply chains.

Key outcomes from the seminar can be summarized as follows:

- **Knowledge enhancement through practice-oriented learning:** Participants highlighted the seminar as a valuable learning experience, particularly due to the use of case studies, practical demonstrations, and clear explanations that helped translate emerging technologies into applicable ideas for industry and research contexts.

- **Capacity building outcomes :** Post-event reflections indicate an overall improvement in participants' self-perceived competence, especially among those with limited prior exposure to AI, IoT, and digital monitoring technologies. The seminar contributed to capacity building not only by increasing participants' awareness of smart manufacturing, but also by strengthening their ability to translate emerging technologies into practical applications within textile production and supply chain contexts. Participants reported a clearer systems-level understanding of how digitalization can improve communication, production efficiency, and integration across the value chain. Beyond general familiarity with concepts such as AI and IoT, many responses reflect movement toward applied thinking that identifying concrete use cases (e.g., monitoring systems, smart IoT devices, and data-enabled process control) and recognizing how digital tools can support operational performance, resilience, and sustainability objectives.

Capacity building outcomes also extend beyond individual learning to include knowledge diffusion and collaboration. Participants repeatedly expressed intentions to share insights within their organizations and across supply chain networks, indicating potential for multiplier effects through internal briefings, experience sharing, and industry-level dissemination. In addition, feedback points to increased openness to collaboration—both cross-organizational and cross-economy—positioning the seminar as a platform for building bridges among enterprises, experts, and institutions. This collaborative dimension is particularly important for accelerating adoption, given that technology implementation in textile supply chains often requires coordinated action among manufacturers, suppliers, customers, and public-sector stakeholders.

In terms of application in home economies, respondents identified several pathways through which the skills and knowledge gained will be used to build broader capacity. These include: (i) developing or refining policy initiatives and sector strategies to promote smart manufacturing adoption; (ii) organizing targeted training programs and leveraging seminar content as a basis for workforce development; (iii) drafting work plans, procedures, and management tools to embed digital practices into routine operations (e.g., job control, monitoring, and production management systems); (iv) initiating pilots at production sites using practical solutions such as IoT-enabled monitoring and AI-supported decision-making; and (v) using the seminar insights to inform technology investment decisions and strengthen organizational readiness for

digital transformation. Overall, the feedback suggests that the seminar helped shift participants from awareness to action, with tangible plans to translate learning into policies, training, operational tools, and collaborative initiatives that can support sustainable modernization of the textile sector.

- **Key academic insights on intended use of skills and knowledge for home-economy capacity building:** Participant responses suggest that the project's capacity-building value lies in its translation of smart manufacturing concepts into actionable pathways for institutional and sectoral change within home economies. A dominant theme is the intention to institutionalize learning through policy and strategic instruments, including the development of new policy initiatives, sector strategies, and structured work plans. This indicates a shift from viewing digitalization as a stand-alone technological upgrade to framing it as a system-level transformation agenda that can be guided by public policy and industry governance.

A second insight concerns the prioritization of implementation-oriented capacity building through human capital development. Respondents frequently identified plans to organize targeted training programs and to repurpose seminar content as curricula for workforce development, particularly for engineers and operational staff. These highlights training as a primary diffusion mechanism for accelerating adoption, while also supporting more standardized competencies for digital transformation across organizations.

Third, participants emphasized embedding digitalization into routine practice by developing new procedures, management tools, and operational systems (e.g., monitoring, job control, production management). Such responses reflect an applied orientation toward institutional change where capacity is strengthened not only through knowledge acquisition, but through the creation of organizational routines and process innovations that sustain performance improvements over time.

Fourth, the feedback underscores an intention to pursue production-site pilots grounded in clear use-cases, such as IoT-enabled monitoring or AI-supported solutions, as an entry point for scaling. This pilot-first approach signals an evidence-seeking logic demonstrating feasibility and value in real settings before expansion, thereby reducing adoption risk and strengthening organizational readiness.

Finally, capacity building is framed as an ecosystem process, with strong emphasis on cross-actor cooperation and international collaboration. Respondent exchange and the exchange and with experts and institutions, building bridges for knowledge exchange, and fostering public–private collaboration. This suggests that participants recognize digital transformation in textile supply chains as a coordination challenge requiring multi-stakeholder engagement. In addition, intentions to disseminate learning through industry platforms, sustainability committees, or other

governance mechanisms reflect a pathway toward institutionalization, whereby project knowledge is embedded into collective structures that can support continuity beyond a single event.

- **Suggested next steps and follow-up actions for APEC:** Participants underscored the importance of advancing the project outcomes beyond knowledge exchange and ensuring that seminar outputs are linked to practical, coordinated actions across APEC economies. The following recommendations are proposed for consideration in future APEC work:

- Shift from dialogue to implementation-oriented cooperation: APEC should establish a clear post-seminar pathway that connects project outcomes to relevant regional cooperation frameworks and prioritize implementation. This may include defining follow-on workstreams, setting shared directions for adoption, and promoting action-oriented initiatives that translate learning into operational change across textile supply chains.
- Strengthening multi-stakeholder and cross-economy linkages: APEC should reinforce platforms that connect key supply chain actors such as manufacturers, suppliers, buyers, government agencies, research institutions, and relevant associations to enable technology diffusion and collaborative problem-solving. Greater participation by public-sector entities, as policy enablers and conveners, would help accelerate uptake, support newcomers, and reduce coordination barriers for technology implementation.
- Prioritize decarbonization and circularity as core follow-up themes: Future APEC activities should explicitly integrate sustainability priorities, especially carbon emission reduction and circular economy approach into the smart manufacturing agenda. Digital technologies (e.g., AI, IoT, monitoring systems) should be positioned as practical enablers for measurement, tracking, and performance improvement, while allowing each economy to align follow-up actions with its domestic policy context and regulatory direction.
- Develop demonstration and replication models for scaling adoption: APEC is encouraged to support demonstration sites and pilot programs across diverse textile segments to showcase practical solutions in real operating environments. Replication-oriented models (i.e., pilots designed for adaptation and scale) should be promoted, particularly approaches that enable AI-supported integration with existing machinery and mixed equipment conditions, thereby lowering investment barriers and improving adoption feasibility.

- Design a sequenced capacity-building program with sustained engagement: Participants recommended continued activities under APEC auspices, including thematic follow-up seminars on emerging technologies, hands-on workshops, and structured study visits. A sequenced program should emphasize productivity and cost-efficiency benefits, practical implementation guidance, and decision-support for technology investment, enabling organizations to convert knowledge into actionable work plans and projects.
- Establish light-touch mechanisms to link outcomes to economy-level actions: To ensure continuity beyond the event, APEC should consider a light-touch follow-up mechanism to encourage and document economy-level actions (e.g., action plans, periodic progress sharing, and peer exchange). A shared repository of best practices, tools, and implementation examples could further support sustained learning, reinforce institutionalization, and enable cross-economic replication of effective approaches.

6. Conclusion

In conclusion, this project demonstrates that the digital transformation of textile supply chains in APEC economies is both an urgent necessity and a concrete opportunity to enhance competitiveness, resilience, and sustainability. The analysis of global and regional trends confirms that the textile industry in the Asia–Pacific region has become deeply embedded in cross-border value chains, while simultaneously facing mounting pressures from climate change, evolving consumer expectations, and increasingly stringent regulations on traceability, ESG disclosure, and circular economy practices. At the same time, the mapping of existing monitoring technologies and solutions indicates that key building blocks RFID, QR/2D codes linked to GS1 Digital Link, IoT, blockchain, and cloud-based SCM networks are already available and have been successfully deployed in selected contexts. The central challenge is therefore not the absence of technology per se, but rather the need to align standards, infrastructure, financing, and human capabilities so that these tools can be scaled and adapted across diverse economies and firm sizes.

The comparative case studies of Australia; China; the United States; and Viet Nam further illustrate that successful cross-regional supply chain monitoring rests on a combination of technological and institutional factors. Common elements include

reliance on international data standards such as GS1 EPCIS/CBV, the use of item-level identifiers (RFID and 2D codes) to enable end-to-end traceability, and the development of multi-enterprise platforms that integrate production, logistics, and financial data in near real time. At the same time, each case highlights distinct pathways shaped by domestic policy frameworks, industrial structures, and market incentives from Australia's sector-wide wool traceability infrastructure to People's Republic of China's integration of RFID, IoT, and manufacturing information systems, to Viet Nam's FDI-driven upgrading and the United States' downstream RFID mandates in retail. Together, these experiences show that digital monitoring systems are most effective when embedded in broader strategies for industrial upgrading, export positioning, and compliance with international sustainability norms.

Survey findings and stakeholder feedback provide additional empirical evidence on regional readiness, needs, and priorities. Overall, technology adoption in APEC's textile sector remains at a low-to-moderate level, with most enterprises situated in early or intermediate stages of digitalization and only a small number of frontrunners approaching full smart manufacturing. Respondents identify sustainable and energy-efficient manufacturing technologies, AI-enabled demand forecasting and energy optimization, and smart automation as particularly impactful for improving productivity and supply chain performance. At the same time, they emphasize that high upfront investment costs, shortages of digital skills, fragmented infrastructures, and misaligned or under-developed standards constitute major barriers to progress. Correspondingly, the most highly ranked strategies focus on investing in shared digital infrastructure, harmonizing data and regulatory frameworks, expanding access to digital skills training, and strengthening mechanisms for knowledge exchange and SME-oriented support.

Against this backdrop, the policy recommendations articulated in the report propose a coherent and sequenced roadmap for action at both domestic and regional levels. They call for tiered policy packages that recognize heterogeneous levels of readiness; the definition of a minimum common regional data set and open standards architecture; the creation of industry-level data hubs and cross-border regulatory sandboxes; and the design of fiscal incentives, concessional finance, and advisory services targeted at SMEs. Equally important are measures to manage transition risks, including the digital divide between large firms and SMEs, potential labor displacement, and concerns regarding personal and commercially sensitive data. The report argues that risk management frameworks must be flexible, evidence-based, and explicitly oriented toward equity, ensuring that digital transformation improves rather

than undermines social and economic inclusion.

Finally, the 2025 International Seminar on the Application of Smart Technology to the Textile Industry (12–13 November 2025) successfully strengthened shared understanding and practical awareness of smart manufacturing and digital transformation in textile supply chains by moving participants from general exposure to applied, use-case thinking. Feedback indicates enhanced capacity not only in individual technical and systems-level comprehension linking AI, IoT, and digital monitoring to productivity, resilience, and sustainability but also in knowledge diffusion and collaboration across organizations and economies, positioning the seminar as a platform for cross-actor coordination. Importantly, participants articulated clear pathways to operationalize learning in home economies through policy and strategic instruments, workforce development and training, the development of procedures and management tools, production-site pilots, and more informed technology investment decisions. Looking ahead, the results point to a coherent agenda for APEC to sustain momentum by shifting from dialogue to implementation-oriented cooperation, strengthening multi-stakeholder linkages, integrating decarbonization and circularity priorities, expanding demonstration and replication models, and establishing light-touch follow-up mechanisms that connect seminar outcomes to coordinated economy-level actions and measurable sector modernization.

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8. Annexes

8.1 Questionnaire

Questionnaire Smart Manufacturing and Digital Transformation in APEC Textile Supply Chains

Instruction: This survey aims to comprehensively assess the current landscape and future direction of smart manufacturing within the textile industry across APEC economies. The findings will support the formulation of evidence-based, actionable policy and industrial recommendations, thereby fostering more resilient, sustainable, and technologically advanced textile manufacturing systems across the APEC region.

Part 1 : Smart Manufacturing Readiness and Technology Adoption in APEC: Regional Needs and Gaps

Q1. How would you assess the overall level of technology adoption in the textile industry across your region's economies?

Please select the option that best represents your perspective:

- a) Very low: Most operations rely on traditional/manual processes
- b) Low: Limited use of basic digital tools with minimal automation
- c) Moderate: Widespread use of conventional technologies and some smart tools
- d) High: Integration of advanced digital technologies in key production stages
- e) Very high: Strong ecosystem for innovation, with full-scale smart manufacturing adoption

Q2. How would you describe the current state of technology adoption in the textile industry of your economy/organization, particularly in relation to production efficiency and smart manufacturing?

Please select the option that best reflects your current situation:

- a) Traditional manufacturing with minimal use of digital technologies
- b) Partial adoption of basic digital tools (e.g., automation in specific

processes)

- c) Moderate integration of smart technologies (e.g., IoT, data analytics in production)
- d) Advanced implementation of smart manufacturing systems (e.g., AI-driven operations, fully digitized supply chains)
- e) Leading-edge technology adoption with continuous innovation and R&D investment

Please briefly describe any key technologies currently in use:

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Q3. Which of the following technologies is most needed in your economy/organization to improve production efficiency in the textile industry?

Please select the most needed technology:

- a) Industrial Automation and Robotics
- b) Internet of Things (IoT) for production monitoring
- c) Artificial Intelligence and Machine Learning
- d) Advanced Data Analytics for decision-making
- e) Enterprise Resource Planning (ERP) Systems
- f) 3D/Virtual Prototyping and Digital Twin technologies
- g) Sustainable or energy-efficient manufacturing technologies
- h) Others (please specify):

Q4. Why are these technologies (from Q3) considered critical? *Please explain their expected impact as well as any potential challenges associated with their*

implementation.

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Q5. Which of the following factors represents the primary barrier to adopting smart manufacturing technologies in the textile industry within your economy?

Please select the most significant factor:

- a) High initial investment costs
- b) Limited access to advanced technologies or infrastructure
- c) Lack of skilled workforce or technical expertise
- d) Unclear return on investment or uncertain economic benefits
- e) Regulatory or policy constraints
- f) Resistance to change within traditional production systems
- g) Limited collaboration between stakeholders (e.g., industry, academia, government)
- h) Others (please specify):

.....

Q6. What are the main regional challenges that make it difficult to adopt smart manufacturing technologies in the textile industry, considering different needs across industries?

Please select the most relevant challenge:

- a) Available technologies do not match the specific needs of local textile producers
- b) Weak connections between supply chain partners in the region
- c) Unequal access to digital infrastructure (e.g., internet, sensors, automation tools)

- d) Lack of financial or government support that fits local industry conditions
- e) Poor cooperation between local businesses, government, and research organizations
- f) No clear guidelines or standards for smart manufacturing in the region
- g) Others (please specify):

Part 2 : Perspectives on Digital Transformation and Strategic Priorities for Enhancing Textile Supply Chain Efficiency in APEC Economies

Q1. In your opinion, which of the following technologies holds the greatest potential for enhancing the textile industry's supply chain efficiency across APEC economies?

Please select the one you consider most impactful:

- a) Artificial Intelligence (AI) and Machine Learning for predictive analytics
- b) Internet of Things (IoT) for real-time monitoring and automation
- c) Blockchain for supply chain transparency and traceability
- d) Cloud-based platforms for integrated supply chain management
- e) Robotics and smart automation for production and logistics
- f) Sustainable manufacturing technologies (e.g., energy-efficient systems, circular production)
- g) Others (please specify):

Q2. Which AI-related applications do you believe are most relevant and impactful for enhancing the textile supply chain in your economy or organization?

Please select up to three options:

(Rank 1 = Most impactful, Rank 2 = Second most impactful, Rank 3 = Third most impactful)

- ___ a) Demand Forecasting – AI analyzes market trends, customer reviews, and social data to predict demand more accurately.
- ___ b) Automated Material Handling – Robotic systems with AI assist in yarn

- loading and equipment setup to reduce labor errors and improve efficiency.
- ___ c) AI-based Textile Digitization – High-resolution imaging and metadata create realistic digital fabrics for faster design and sampling.
- ___ d) 3D Cloth Simulation – AI simulates fabric drape and behavior for virtual prototyping and design accuracy.
- ___ e) AI-Driven Quality Control – Computer vision detects defects (e.g., weave flaws, color mismatch) in real-time during production.
- ___ f) Energy Optimization – AI tracks and optimizes energy usage throughout the manufacturing process.
- ___ g) Predictive Maintenance – AI uses sensor data (vibration, tension) to forecast machine failures and minimize downtime.
- ___ h) Virtual Sampling & Customization – Digital tools enable virtual samples and personalized designs without physical waste.
- ___ i) Others (please specify):

Q3. What are the main challenges or enablers for adopting AI-related applications in your textile supply chain?

Please write in short paragraphs or bullet points:

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Q4. In your opinion, how well is your economy prepared, both in terms of technology and institutional support, to promote digital transformation across the entire textile supply chain?

Please select one:

- a) Not prepared – no strategic plans or resources in place
- b) Minimally prepared – only initial discussions or plans underway
- c) Moderately prepared – some digital initiatives are in progress
- d) Well prepared – clear roadmap and targeted investments are in place
- e) Fully prepared – large-scale implementation is actively ongoing
- f) Not sure / No information available

Q5. Please rank the top three strategies you believe are most effective in driving digital transformation in the textile supply chain among APEC member economies.

Please select up to three options:

(Rank 1 = Most important, Rank 2 = Second most important, Rank 3 = Third most important)

- a) Investing in shared digital infrastructure across APEC economies
- b) Harmonizing data standards and regulatory frameworks region-wide
- c) Facilitating cross-economy knowledge exchange and best practice sharing
- d) Expanding access to digital skills training for supply chain actors
- e) Offering financial and policy incentives for technology adoption
- f) Establishing regional innovation hubs and public-private partnerships
- g) Others (please specify):

Q6. What are the primary challenges or barriers your economy faces in implementing the selected strategies to drive digital transformation in textile supply chain?

Please select up to three options:

(Rank 1 = Most challenges/ barriers, Rank 2 = Second most challenges/ barriers, Rank 3 = Third most challenges/ barriers)

- a) Limited financial resources or investment capacity
- b) Lack of coordinated policy support across sectors
- c) Shortage of skilled professionals in digital technologies
- d) Low awareness or resistance to change among key stakeholders
- e) Fragmented infrastructure or digital systems across regions
- f) Difficulty in aligning cross-border regulations and standards
- g) Others (please specify):

Q7. What policy recommendations would you propose to promote digital transformation in the textile supply chain among APEC member economies? Please explain your suggestions based on your experience or local context.

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Q8. Would you be interested in participating as a speaker or contributor in the upcoming International Seminar on the Application of Smart Textile Technology?

Please select one:

- a) Yes, I would be interested in participating as a speaker
- b) Yes, I would be interested in contributing to another capacity (e.g., panelist, expert commentator)
- c) Maybe, depending on the topic and availability
- d) No, I am not interested currently

Part 3 : Basic Information

Q1. Name of your organization:.....

Q2. Your economy:

- a) Australia
- b) Brunei Darussalam
- c) Canada
- d) Chile
- e) People's Republic of China
- f) Hong Kong, China
- g) Indonesia
- h) Japan
- i) Republic of Korea
- j) Malaysia
- k) Mexico
- l) New Zealand
- m) Papua New Guinea

- n) Peru
- o) The Republic of the Philippines
- p) The Russian Federation
- q) Singapore
- r) Chinese Taipei
- s) Thailand
- t) United States
- u) Viet Nam

Q3. Type of your organization:

- a) Textile Manufacturer
- b) Technology Provider (e.g., ICT, automation)
- c) Government Agency / Policy Body
- d) Research / Academic Institution
- e) Non-profit or Industry Association
- f) Environmental or Sustainability Organization
- g) Other (please specify):

Q4. Your Position / Title:

Q5. Years of Experience in the Textile or Related Industry:

- a) Less than 3 years
- b) 3–5 years
- c) 6–10 years

d) More than 10 years

Q6. Primary Area of Expertise:

a) Textile production and operations

b) Supply chain and logistics

c) Smart manufacturing technologies

d) Sustainability and environmental practices

e) Industrial policy or strategy

f) Research and development

g) Other (please specify):

Q7. Have you or your organization previously participated in international forums on textile innovation or digital transformation?

a) Yes

b) No

c) Not sure

Q8. Preferred method of future engagement with APEC activities on textile innovation:

You may select more than one:

a) Attending international seminars/webinars

b) Participating as a speaker or expert

c) Contributing to working groups or research

d) Receiving policy updates and technical reports

e) Collaborating on pilot projects or case studies

8.2 Basic Information of Respondents

Issue	Sub-issue	Number	%
Economy	Indonesia	1	3.23%
	Peru	4	12.90%
	Singapore	1	3.23%
	Chinese Taipei	24	77.42%
	Thailand	1	3.23%
	Total	31	100.00%
Type of organization	Textile Manufacturer	25	80.65%
	Technology Provider (e.g., ICT, automation)	2	6.45%
	Research / Academic Institution	1	3.23%
	Non-profit or Industry Association	2	6.45%
	Sourcing and Sustainability Consulting Company	1	3.23%
	Total	31	100.00%
Years of Experience in the Textile or Related Industry	3–5 years	5	16.13%
	6–10 years	2	6.45%
	More than 10 years	24	77.42%
	Total	31	100.00%
Primary Area of Expertise	Textile production and operations	17	54.84%
	Supply chain and logistics	1	3.23%
	Smart manufacturing technologies	2	6.45%
	Commercial Area	1	3.23%
	Sustainability and environmental practices	2	6.45%
	Industrial policy or strategy	1	3.23%
	Research and development	3	9.68%
	Finance	1	3.23%
	Sales and Corp management	1	3.23%
	Textile Operations, Product Development and Quality Assurance	1	3.23%
	Construction Management	1	3.23%
	Total	31	100.00%