Transition from TQM to Quality 4.0

Executive Summary

Total Quality Management (TQM) is a people-centred and customer-focused management system that seeks continuous improvement through the involvement of the entire organisation. Quality 4.0 (Q4.0) does not supersede TQM; rather, it extends its principles into the Industry 4.0 environment, where decision-making increasingly relies on connected data, analytics, automation and algorithmic support. The American Society for Quality (ASQ) presents Q4.0 as the future of quality in response to the demands of Industry 4.0, while LNS Research defines it as the application of industrial transformation methodologies and digital technologies to transform quality across the value chain. [1]

There is currently no single official international statistic that directly measures "Q4.0 adoption". The ISO Survey and IAF CertSearch mainly track management-system certifications, while Eurostat and the Hellenic Statistical Authority (ELSTAT) measure specific digital capabilities, such as AI, cloud computing and data analytics. Consequently, this report uses documented proxy indicators: the adoption of AI, cloud, data analytics and IIoT; investment in smart manufacturing; governance maturity; and applicable standards. [2]

Globally, the picture is mixed. On the one hand, the technological foundation is expanding rapidly. McKinsey reports that in 2025, 78% of organisations used AI in at least one business function, and 71% regularly used generative AI in at least one function. In a major manufacturing survey, Deloitte found that 57% used cloud computing and 57% used data analytics at the plant or network level, while 46% used IIoT, 29% AI/ML and 24% generative AI. On the other hand, mature deployment at scale remains more limited: BCG reports that only approximately one in four companies derives significant value from AI, while Gartner associates a substantial proportion of failed initiatives with inadequate data, governance, risk controls and measurement. [3]

In Greece, the transition is at an early but accelerating stage. ELSTAT reports that, in 2025, 8.2% of enterprises with internet access used AI systems, 26.1% conducted data analysis using their own employees, and 31.8% conducted data analysis internally or through an external provider. Eurostat reports that in Greece, just 24.3% of enterprises used paid cloud services in 2025, compared with 52.7% across the EU. Meanwhile, Greece's national Digital Decade roadmap sets 2030 targets of 56% for cloud, 40% for big data/data analytics and 32% for AI, starting from low official baselines in 2020–2021. [4]

The central conclusion is that moving from TQM to Q4.0 is not a software project but a transformation of the operating model. It requires the simultaneous digitalisation of core quality processes; integration of OT, IT and data; new governance for AI and data; workforce upskilling; coordination across Quality, Operations, IT and Security; and value measurement using both traditional and new KPIs. The Greek enterprises likely to gain an early advantage will be those that begin not with "technology for technology's sake", but with three to five use cases supported by a compelling business case: in-line quality monitoring, predictive quality, digital CAPA, supplier quality, complaint intelligence and digital traceability. [5]

TQM and Q4.0: Successive, Not Competing, Paradigms

ASQ describes TQM as a management system for a customer-focused organisation that involves all employees in continuous improvement, using strategy, data and communication to embed quality in processes, products, services and culture. ISO's seven quality management principles—customer focus, leadership, engagement of people, process approach, improvement, evidence-based decision-making and relationship management—remain the most useful foundation for TQM and are, in essence, carried forward into Q4.0. [6]

Q4.0, by contrast, is an umbrella term for the transition of quality management into a world of connected systems, digital workflows, real-time analytics and AI-assisted decision-making. ASQ describes it as the evolution of quality in response

to the needs and expectations of Industry 4.0. LNS Research defines it as the transformation of quality management across products, procurement, operations, logistics and customer experience through industrial transformation methods and emerging digital technologies. The literature stresses that installing technology is not enough: Q4.0 also requires new leadership capabilities, organisational readiness, interoperability, high-quality data and active involvement by quality professionals. [7]

The essential distinction, therefore, is not that TQM "ends" and Q4.0 "begins". The actual shift is from predominantly people-organised continuous improvement to people-led but digitally accelerated quality management, offering real-time visibility, predictive detection of deviations, closed-loop actions and a broader scope extending from the shop floor to customers and suppliers. Systematic reviews associate Q4.0 with real-time monitoring, defect prediction, in-line inspection and end-to-end visibility. [8]

The following table synthesises this transition based on ASQ, ISO and the international Q4.0 literature. [9]

Dimension	TQM	Q4.0
Strategic objective	Continuous improvement, reduction of deviations, customer satisfaction	Continuous improvement in real time, driven by data and predictive approaches
Role of data	Sampling, reports, SPC, audits, historical analysis	Streaming data, industrial data models, advanced analytics, AI/ML, digital traceability
Decision-making cadence	Periodic, through PDCA/Kaizen cycles	Near-continuous, supported by alerts, dashboards and model-assisted decisions
Scope	Primarily process/product quality and culture	End-to-end quality: design, suppliers, production, logistics, service, customer feedback
Tools	PDCA, Lean, Six Sigma, SPC, audits, CAPA	Traditional tools plus IoT, cloud, computer vision, AI, digital twins and low-code workflows
Organisational structure	Quality function as guardian of the management system	Cross-functional model connecting Quality, Operations, Data and Security
Skills	Quality engineering, audits, SPC, Lean facilitation	All of the preceding, plus data literacy, model governance, OT/IT integration and digital product ownership
Governance	ISO/QMS compliance, management review	QMS governance plus data governance, AI governance, cybersecurity and model monitoring
Improvement horizon	Incremental improvement	Incremental, predictive and autonomous/closed-loop improvement
Main risk of failure	Formal compliance without an improvement culture	Technology without adequate data foundations, leadership, adoption and trust

Technologies and the Operating Model of the Transition

Technologies Enabling Q4.0

The technological foundation of Q4.0 is not a single platform but a technology stack. LNS Research and ASQ explicitly refer to AI/ML, connected devices, Big Data, cloud computing and new forms of digital collaboration. ISO 23247 provides a standards framework for digital twins in manufacturing, while ISO 22400 establishes the logic of KPIs for manufacturing operations management. ISO/IEC 42001 and the NIST AI Risk Management Framework (AI RMF) add the governance layer required when AI is used in critical quality operations. [10]

Technology	What it does in practice	Typical quality use cases	Business impact
IoT / IIoT	Connects machinery, sensors, production lines and the production environment	In-line monitoring, condition monitoring, traceability	Faster detection of deviations; fewer blind spots
AI / ML	Identifies patterns and predicts defects, anomalies and drift	Predictive quality, computer-vision inspection, anomaly detection	Less rework and scrap; improved failure prediction
Big Data / Analytics	Combines data from processes, quality, the supply chain and customers	Root-cause analysis, COPQ analytics, complaint mining	Deeper causal analysis and faster decisions
Digital twins	Creates digital representations of manufacturing elements and the information exchanged between them	Process simulation, what-if analysis, predictive optimisation	Less trial and error; improved commissioning
Cloud	Provides scalable infrastructure, computing, storage and SaaS QMS capabilities	Multi-site QMS, supplier portals, analytics at scale	Faster scaling and less deployment friction
Edge computing	Processes information close to production, with low latency	Vision inspection, local alarms, line-side SPC	Faster response at line level and less dependence on WAN connectivity
Workflow / low-code	Digitalises workflows, approvals, CAPA and deviations	Digital CAPA, deviation management, audit trails	Shorter resolution cycles; less reliance on email and spreadsheets
Cybersecurity / OT security	Protects industrial automation and control systems (IACS), OT and quality data	Secure shop-floor connectivity, access control, resilience	Lower cyber risk and less downtime

Synthesis based on ASQ, LNS Research, ISO, NIST and ISA. [11]

The Organisational Changes Required

One of the most common misconceptions is that Q4.0 is an IT project. International research and maturity studies suggest otherwise: major barriers include skills gaps, insufficient resources, weak executive sponsorship, high costs, legacy systems, resistance to change and an unclear vision. Gartner also identifies data availability and quality as major obstacles to AI implementation, while higher-maturity organisations are substantially more likely to use metrics and sustain operational AI projects over time. [12]

In practice, this entails four operational shifts. First, Quality ceases to be solely an inspection and control function and becomes an orchestrator of quality, data and improvement. Second, the operating structure requires joint ownership by Quality, Operations, IT/Data and Security. Third, the culture changes from “find the problem at the end” to “anticipate and correct it as it emerges”. Fourth, quality-related skills expand beyond SPC, audits and CAPA to include data literacy, understanding of models and model risk, data lineage, OT/IT integration and change facilitation. [13]

An appropriate Q4.0 operating model for most medium-sized and large enterprises includes a management-level Quality Council; use-case owners for each value stream; a data steward for critical quality data; MLOps/model governance for models that make or influence decisions; and common standards for master data, events, traceability, cybersecurity and KPI definitions. This architecture is consistent with the principles of ISO 9001 and the frameworks of ISO 22400, ISO 23247, ISO/IEC 42001 and ISA/IEC 62443. [14]

Global Trends and Adoption Rates

What Exactly Is Measured When We Discuss Adoption?

Because there is no official international time series for "Q4.0 adoption", the safest approach is to distinguish three levels of maturity:

1. **Enabling technologies:** cloud, data analytics, AI, IIoT and digital workflows.
2. **Operational applications:** in-line quality monitoring, predictive maintenance/quality, digital CAPA, supplier quality and complaint analytics.
3. **Mature Q4.0:** integrated data models, interoperable systems, governance, metrics, deployment across multiple sites and closed-loop improvement.

This distinction matters. McKinsey counts AI adoption even when it means early-stage use in a single function, whereas Gartner and BCG show that moving from experimentation to value creation at scale remains much harder. [15]

Evidence from Major International Sources

McKinsey reports that in 2025, 78% of organisations used AI in at least one business function, and 71% regularly used generative AI in at least one function. McKinsey also clarifies that "adoption" spans everything from initial experimentation to full integration across multiple units. These percentages therefore indicate technology diffusion, not necessarily mature Q4.0. [16]

Deloitte finds that foundational Q4.0 technologies are entering a more mature phase in large manufacturing enterprises: 57% use cloud computing and 57% use data analytics at the facility or network level; 46% use IIoT, 42% 5G, 29% AI/ML and 24% generative AI. Furthermore, 78% allocate more than 20% of their total improvement budget to smart manufacturing initiatives. Respondents also report improvements of 10%–20% in output, 7%–20% in productivity and 10%–15% in unlocked capacity following implementation. [17]

BCG applies a stricter test based on realised value: only approximately 26% of companies manage to generate significant value from AI. In other words, the market has moved beyond "we need to do something with AI", but has not yet reached "AI is fully integrated and consistently generates business value". This closely reflects the distinction between partial digitalisation of quality and mature Q4.0. [18]

Gartner reinforces this picture from a risk perspective. It predicted that by the end of 2025, at least 30% of generative AI projects would be abandoned after the proof-of-concept stage, and that by 2026 organisations would abandon 60% of AI projects unsupported by AI-ready data. In a survey of AI maturity, only 45% of high-maturity organisations sustained AI projects in operation for at least three years, while data availability and quality ranked among the main obstacles. [19]

From an investment perspective, IDC indicates a shift from experimentation towards strategic operations: European AI spending is forecast to reach $290 billion by 2029, representing a compound annual growth rate (CAGR) of 33.7% in 2025–2029. IDC explicitly notes that organisations are moving from experimentation towards operational and strategic deployment. This trend does not automatically equate to Q4.0 adoption, but strongly suggests that enabling technologies will become mainstream rapidly. [20]

IEEE offers a complementary signal from technology leaders. In its global "Impact of Technology 2025" study, 58% considered AI the most important technology field for the following year; 20% said they were already using generative AI regularly with added value, 24% were planning practical applications, and more than 30% were experimenting through small projects. This reinforces the view that the market is transitioning from awareness and pilots towards operational use cases at scale. [21]

Evidence-Based Assessment of Adoption Rates

Taken together, these findings support the following assessment:

- **Partial adoption of Q4.0 elements is already widespread globally.** Under a loose definition such as "AI used in at least one function", adoption is already very high. [22]
- **Adoption in industrial environments is lower, but increasing strongly.** Deloitte's cloud, analytics, IIoT and AI figures indicate that a substantial number of large enterprises have moved beyond isolated pilots. [17]
- **Mature, scaled adoption remains a minority practice.** When defined as integration into the operating model with governance, shared data, measurable business value and deployment across multiple sites, a reasonable evidence-based inference places mature Q4.0 adoption in the low double digits to approximately one quarter of large industrial organisations globally, while the wider market lags considerably. **This is not an official statistic:** it is an inference combining McKinsey, Deloitte, BCG and Gartner evidence. [23]

Europe also has an explicit policy objective: by 2030, three in four EU enterprises should use cloud computing, big data or AI, and more than 90% of SMEs should achieve at least a basic level of digital intensity. This creates a strong institutional context for accelerating Q4.0 over the coming years, even though the full convergence of Quality, Data and AI is likely to trail individual technologies by at least one maturity cycle. [24]

Greece as a Distinct Case in the Transition

What the Official Data Show

Greece starts from a lower baseline. Under its national Digital Decade roadmap, the official starting points are 15.2% for cloud computing in 2021, 12.9% for big data/data analytics in 2020 and 2.6% for AI in 2021, with corresponding targets of 56%, 40% and 32% by 2030. The roadmap itself acknowledges that Greece trails the EU in cloud and AI adoption and sets out measures ranging from European Digital Innovation Hubs (EDIHs) to smart manufacturing and industrial data platforms. [25]

ELSTAT's 2025 figures provide a particularly useful snapshot of business digital maturity: 98.7% of enterprises with at least ten employees have internet access; 26.1% perform data analytics using their own employees; 31.8% perform data analytics either in-house or through an external provider; and 8.2% use AI systems for at least one purpose. However, the same publication cautions that the 2025 figures are not directly comparable with those of 2024 because of a change in the statistical reporting unit. [26]

Eurostat complements this picture by highlighting the cloud gap: in 2025, 52.7% of EU enterprises used paid cloud services, compared with just 24.3% in Greece. The EU average for enterprise AI use reached 20.0% in 2025. Thus, even if Greece is improving, convergence will need to accelerate substantially to close the gap. [27]

In its *Greece 2025 Digital Decade Country Report*, the European Commission states that the Greek roadmap includes 125 measures with estimated public funding of €6.1 billion. The national strategy also reports that Greece's seven established EDIHs cover all geographical regions and are expected to support more than 500 SMEs. [28]

Implications for Q4.0 in Greece

On the basis of these indicators, Greece is predominantly in the digital quality enablement phase rather than in a period of widespread mature Q4.0 adoption. The 31.8% figure for analytics activity is encouraging; however, AI adoption of 8.2% and cloud adoption of 24.3% show that the combined technological foundation needed for a mature Q4.0 programme remains relatively weak. Because Q4.0 requires connectivity, data, analytics, governance and organisational adoption to operate together, the actual rate of mature adoption must be lower than any individual technology indicator. This is an evidence-based assumption, not an official statistic. [29]

A realistic interpretation is therefore that mature Q4.0 in Greece is currently concentrated in large, internationally oriented or technology-intensive companies, while partial and pilot implementations predominate among SMEs. Across the economy, mature adoption is probably in the single digits to low double digits, whereas partial or pilot adoption is appreciably more widespread. Without an official Q4.0 time series, a more precise estimate would require a primary survey. [30]

Signs of Maturity and Greek Case Examples

Despite the lower national averages, there are important pockets of excellence. TITAN reports that it is building the "smart cement plant of the future", using AI-based real-time optimisers with thousands of sensors, real-time optimisation and predictive maintenance. Reported benefits include higher productivity and reductions in energy consumption and CO_2 emissions. In publicly available material, TITAN cites productivity improvements of up to 10% from AI-based real-time optimisers. [31]

Viohalco/Sidenor reports using digital technologies to assess scrap quality and optimise electric arc furnace processes, as part of investments in product quality advancement, automation and digital transformation. This exemplifies the Q4.0 principle of embedding quality within production data and optimisation. [32]

Papastratos does not publish quality-specific Q4.0 metrics at the same level of detail, but describes real-time energy monitoring, thermal-process optimisation and smart load management at its Aspropyrgos plant as part of advanced industrial innovation. This example mainly indicates that Greek manufacturing is moving towards connected industrial operations, even though the published evidence focuses more on sustainability and energy transformation than on quality transformation. [33]

Greece also has an interesting solutions ecosystem. Atlantis Engineering positions itself as a Greek provider of predictive maintenance and CMMS solutions supported by IIoT. SenseOne offers a cloud-based IoT data analytics platform for monitoring and energy/manufacturing applications. Prisma Electronics has developed LAROS, a specialised IoT platform for remote monitoring and analytics. While these companies are not all exclusively "quality software" providers, they represent important building blocks of Greece's Q4.0 ecosystem. [34]

The Pace Greece Needs to Achieve by 2030

Looking at cloud and AI alone, the gap is substantial. Increasing cloud adoption from 24.3% in 2025 to the 2030 target of 56% requires approximately **6.3 percentage points per year**. Moving from approximately 8.2% AI adoption in 2025 to the target of 32% requires around **4.8 percentage points per year**. These rates are ambitious but not impossible, provided the market rapidly shifts from fragmented, subsidised purchases to coordinated transformation programmes built on standards, capabilities, vendor ecosystems and EDIHs as "test-before-invest" mechanisms. These calculations are derived from official baseline values and targets. [35]

Illustrative Timeline: From TQM to Q4.0

Year	Development or milestone
2017	The term "Quality 4.0" becomes established in industry discussion.
2021	Greece's official baseline: 2.6% AI adoption and 15.2% cloud adoption.
2022	Stronger emphasis on industrial transformation and manufacturing digitalisation programmes.
2025	78% of surveyed organisations use AI in at least one function; Greece reports 8.2% AI use, 24.3% cloud adoption and 31.8% data analytics activity.
2029	Forecast European AI spending reaches approximately $290 billion.
2030	Greece's targets: 32% AI, 56% cloud and 40% big data/data analytics.

The timeline combines official measurement points and proxy indicators of adoption. [36]

Transition Framework, KPIs and Risk Management

A Practical Transition Framework

An effective transition begins with diagnosis, not with the purchase of a platform. Organisations should first assess the maturity of their existing TQM/QMS, data quality, availability of process data, OT/IT architecture and governance gaps. Next, they should prioritise a limited set of use cases, establish a data foundation and digitalise core quality workflows. Only then should pilots be launched, with explicit criteria governing whether and how they will be scaled up. This approach is fully consistent with TQM's process approach and evidence-based decision-making and with Q4.0's requirements for data/AI governance and secure industrial systems. [37]

Recommended sequence of work:

Assess TQM/QMS maturity → Select high-value use cases → Establish data foundations and OT/IT integration → Digitalise core quality workflows → Run pilots with defined scale-up criteria → Implement AI/data governance and cybersecurity → Scale across sites and processes → Continuously improve and monitor performance.

A practical set of anchor standards is: ISO 9001 and the quality management principles for the management foundation; ISO 22400 for manufacturing KPI logic; ISO 23247 for digital twin architecture; ISO/IEC 42001 and NIST AI RMF for AI governance; and ISA/IEC 62443 for OT/industrial cybersecurity. [38]

KPIs and How to Measure Success

Q4.0 does not replace traditional quality KPIs. It complements them with measures of digital maturity, data quality and AI reliability. ISO 22400 provides an industry-neutral framework for KPIs in manufacturing operations management, while Gartner's findings indicate that more mature organisations are much more likely to apply formal metrics to AI programmes. [39]

KPI group	Illustrative indicators	Why they matter
Traditional quality	FPY, scrap %, rework %, defects PPM, customer complaints, warranty rate	Shows whether quality is actually improving
Process capability	Cp, Cpk, control-limit stability, process drift	Measures stability and control of variation
Speed and workflow	CAPA cycle time, deviation closure time, audit closure, time-to-detect/time-to-correct	Shows whether digitalisation accelerates response
Economic value	COPQ, avoided downtime, unlocked capacity, inventory impact, ROI/NPV	Connects Q4.0 to business outcomes
Data foundation	% of critical assets connected, data completeness, latency, master-data accuracy, lineage coverage	Establishes whether reliable automation is feasible
AI / Analytics	Precision, recall, false positives, model drift, % of decisions assisted by models	Evaluates whether AI is reliable and useful
People adoption	Training completion, active users, % of workflows digital, override rate, operator trust score	Shows whether Q4.0 is genuinely used
Resilience / Risk	Cyber incidents, OT patch compliance, backup recovery tests, model governance exceptions	Assesses whether the system is secure and controlled

The proposed measurement method is **baseline → pilot → control comparison → scale gate → quarterly management review**. For use cases such as vision inspection or predictive quality, both the technical KPI of the model and the

operational KPI of the production line should be measured. If the latter does not improve, Q4.0 has not been achieved, even if the algorithm performs well in the lab. This is the most important distinction between an "AI project" and a "quality transformation". [40]

Risks and Change Management

Five principal risks arise during the transition to Q4.0. First is *pilot purgatory*: numerous proofs of concept with little operational value. Second is poor data quality or an immature data foundation. Third is the difficulty of integrating legacy systems. Fourth is human resistance and insufficient skills. Fifth is cybersecurity and AI governance. Findings from Gartner, McKinsey and systematic reviews are broadly consistent on these points. [41]

Risk	How it manifests	Mitigation
Experimentation without scale	Many pilots, no multi-site rollout	Stage gates, accountable owner, value case, architecture designed from the outset
Poor-quality data	False alarms, unreliable dashboards, model failures	Data steward, master data, observability, clear rules
Technology-first approach	Software purchased without process redesign	Begin with use cases and operational pain points
Skills gap	Low adoption, excessive dependence on vendors	Upskill Quality, Operations, Engineering and IT
OT/IT cyber risk	Attacks, downtime and erosion of trust	ISA/IEC 62443 controls, access management, segmentation
AI governance gap	Bias, opaque decisions and audit issues	ISO/IEC 42001, NIST AI RMF, model registries
Control culture rather than improvement	Technology becomes "digital bureaucracy"	Kaizen principles, frontline involvement, visible quick wins

Platforms, Suppliers and Recommendations for Greece

Illustrative Map of Vendors and Platforms

The Q4.0 solutions market typically falls into four categories: enterprise/cloud QMS; manufacturing execution and operations platforms; IIoT/analytics platforms; and Greek systems integrators or platform providers. Most enterprise solutions do not publish official price lists, so costs are often not publicly available. Some low-code and frontline platforms are exceptions. [42]

Vendor / Platform	Country	Primary function	Suitability for Q4.0	Cost
Siemens Opcenter X Quality	Germany	Cloud QMS for shop-floor quality, inspections, SPC and nonconformance management	Strong fit for manufacturing-centric digital quality	Not publicly available
SAP S/4HANA Cloud Quality Management	Germany	Embedded quality management within the cloud ERP/manufacturing stack	Appropriate for end-to-end ERP-driven governance	Not publicly available
Octave ETQ Reliance	USA	eQMS with document control, CAPA, audits, analytics and quality events	Very strong in enterprise eQMS and compliance-heavy environments	Not publicly available
MasterControl Quality Excellence	USA	Digital QMS for highly regulated industries	Strong in life sciences, pharmaceuticals and medical devices	Not publicly available
Honeywell TrackWise Digital	USA	SaaS digital quality ecosystem and digital manufacturing procedures	Strong in proactive quality and regulated manufacturing	Not publicly available
PTC ThingWorx + quality/IIoT stack	USA	IIoT/AI platform, manufacturing applications and closed-loop performance	Appropriate where quality is connected to assets and operational data	Not publicly available

Vendor / Platform	Country	Primary function	Suitability for Q4.0	Cost
Tulip Frontline Operations Platform	USA	Low-code frontline applications for quality, assembly, visibility and analytics	Suitable for rapid pilots, operator guidance and digital work instructions	$100/month per interface, with a minimum of 10 interfaces under the Essentials plan
Atlantis Engineering	Greece	Predictive maintenance, CMMS and IIoT-driven maintenance	Strong building block for reliability- and maintenance-driven Q4.0	Not publicly available
SenseOne IoT Platform	Greece	Cloud-based IoT data analytics platform	Suitable for monitoring, energy/ manufacturing analytics and the data layer	Not publicly available
Prisma Electronics / LAROS	Greece	IoT remote monitoring and analytics platform	Suitable as a data/monitoring platform in specialised industrial use cases	Not publicly available

Supporting sources: Siemens Opcenter X Quality [43]; SAP Manufacturing & Quality [44]; ETQ Reliance [45]; Master-Control [46]; Honeywell TrackWise Digital [47]; PTC ThingWorx [48]; Tulip [49]; Atlantis Engineering [50]; SenseOne [51]; Prisma Electronics [52].

Recommended Business and Policy Directions for Greece

For Greece, an effective strategy is not to replicate everything the most mature countries are doing at once. It is to accelerate through sector-specific specialisation and measurable industrial use cases. Public support should therefore be linked not merely to equipment purchases but to quality outcomes: lower cost of poor quality (COPQ), demonstrable improvement in first-pass yield (FPY), reduced downtime, traceability readiness and digitalised compliance. The Hellenic Federation of Enterprises (SEV) has already pointed out that progress across Industry 4.0 initiatives was uneven and slow, with many actions still at an early stage. [53]

The most useful policy steps for Greece would be as follows. First, establish a national observatory for industrial digital maturity and Q4.0 with a common methodology involving ELSTAT, universities, SEV and sectoral associations. Second, use EDIHs as “test-before-invest” facilities specifically for digital quality use cases. Third, link smart manufacturing, SME digital transformation and research/innovation programmes to standardised adoption and impact KPIs. Fourth, develop sector playbooks for food and beverages, pharmaceuticals, metals and construction materials—industries in which Greece has substantial productive capacity. Fifth, strengthen Quality–Data–Engineering skills through micro-credentials developed with EDIHs and higher-education institutions. Much of the necessary funding is already envisaged in the national roadmap and related programmes. [28]

Recommended Next Steps for a Typical Greek Industrial Enterprise

The following table is **not a market price list**. It presents planning assumptions for a medium-sized industrial enterprise in Greece, to help structure a realistic transformation programme. Where official public software pricing is unavailable, the estimate is indicative only.

Next step	Typical duration	Internal resources	Indicative cost	Goal
Diagnostic TQM/Q4.0 maturity assessment	4–8 weeks	CEO/COO sponsor, Head of Quality, IT, Production	€15,000–€40,000	Clear baseline and use-case backlog
Data foundation and architecture blueprint	6–10 weeks	IT/data lead, OT engineer, quality engineer	€20,000–€60,000	Data model, integrations, governance rules
Digitalisation of core QMS workflows	2–4 months	Quality team, process owners, vendor	€25,000–€100,000	Digital CAPA, deviations, audits and nonconformances
In-line quality / vision / SPC pilot	3–6 months	Production, Quality, Automation, vendor	€60,000–€200,000	Less scrap/rework on a critical production line

Next step	Typical duration	Internal resources	Indicative cost	Goal
Predictive quality / predictive maintenance pilot	4–8 months	Operations, Maintenance, data team	€80,000–€250,000	Predict deviations and reduce downtime
Scale-up to a second or third line or facility	6–12 months	Programme manager, plant managers, Security	€100,000–€400,000	Repeatability and multi-site governance
Upskilling and change programme	Ongoing	HR, Quality, Operations, IT	€10,000–€50,000 per year	Adoption, trust and skills readiness
AI governance and OT security hardening	2–6 months	Security, IT/OT, Legal, Quality	€20,000–€100,000	Auditability, resilience and compliance

The recommended sequence makes the first two steps mandatory, then selects only two pilots with clearly defined business value. For most Greek companies, the most appropriate initial use cases are digital CAPA, in-line inspection, quality analytics for scrap and rework, supplier quality portals, and predictive maintenance at production bottlenecks.

Open Issues and Limitations

The most important limitation of this analysis is the absence of official statistics on “Q4.0 adoption”, both internationally and in Greece. Consequently, proxy indicators from AI, cloud, analytics, Industry 4.0 and smart manufacturing have been used. In Greece, ELSTAT explicitly notes that the 2025 results are not directly comparable with those for 2024 because of a methodological change. Accordingly, Q4.0 adoption ranges cited in this report are evidence-based estimates, not official measurements. [54]

A second limitation is that most enterprise vendors in this market do not publish official pricing. Comparative tables therefore indicate that most prices are “not publicly available”, while the implementation roadmap includes planning assumptions only. [55]

The key next requirement for Greece is a national, recurring survey of Q4.0 maturity by manufacturing sector. Without one, the country will continue to measure separate technological components of the challenge rather than the actual transformation of quality management.

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