

INDUSTRY 5.0 AND MANAGEMENT ACCOUNTING: BRIDGING DIGITAL TRANSFORMATION AND BUSINESS VALUE

Abstract

Industry 5.0 builds on the efficiency-centric logic of Industry 4.0 by focusing on human-centricity, sustainability and resilience. The transition requires organisations to think beyond technology adoption and consider whether digital investments generate tangible economic, operational, human and environmental value. This conceptual paper shows how management accounting can create that link. It develops the framework Digital Technologies → Industry 5.0 Capabilities → Management Accounting → Enterprise Value. It integrates an Industry 5.0 Management Accounting KPI framework that covers financial value, operational excellence, human-centricity, sustainability, resilience, digital capability and governance. Management accounting tools such as activity-based costing, lifecycle costing, rolling forecasts, variance analysis, scenario analysis and investment appraisal are associated with technologies including artificial intelligence and machine learning (AI/ML), the industrial Internet of Things (IIoT), digital twins, cloud/edge computing, blockchain, collaborative robots and augmented/virtual reality. The article then goes on to show how technology investments can be evaluated using NPV, risk analysis and strategic non-financial criteria. It contends that management accountants should have a growing role as translators of digital information into decisions on cost, performance, capital allocation, risk and long-term enterprise value.



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Introduction

Industry 4.0 created a technology-driven model with automation, connectivity, data analytics and intelligent production. Industry 5.0 does not dismiss these capabilities but

instead contextualises them within a broader framework of human-centric, sustainable and resilient value creation (European Commission, 2021; Leng et al., 2022). More specifically, the European Commission positions Industry 5.0 as a complement to Industry 4.0, but with a new focus on stakeholder value and industrial resilience.

This is an important managerial implication. Digital technologies produce a lot of operational information, but information does not create value by itself. Management must convert information into decisions about costs, capacity, investment, risk, and workforce capability and sustainability. Management accounting thus becomes an important translation mechanism between technological capability and enterprise value.

The article attempts to fill this gap by developing

a conceptual relation between digital technologies, Industry 5.0 capabilities, management accounting and enterprise value. It also enriches the management accounting dimension with specific accounting tools, KPIs and decision applications and introduces technology investment appraisal as an integral part of Industry 5.0 implementation.

Management Transition from Industry 4.0 to Industry 5.0

Industry 5.0 is usually described with three interrelated principles, i.e., human-centricity, sustainability and resilience (Nahavandi, 2019; European Commission, 2021; Leng et al., 2022). The human-centric aspect is stressed by Nahavandi (2019) and the wider sustainability and resilience agenda is expanded by subsequent literature.

Table 1. Industry 4.0 and Industry 5.0: the management comparison

Dimension	Industry 4.0	Industry 5.0
Core orientation	Automation, connectivity and efficiency	Human-centric, sustainable and resilient value creation
Role of technology	Automate and optimise processes	Augment people and enable responsible decisions
Performance logic	Productivity, quality and cost outcomes	Financial, social, environmental and resilience outcomes
Human role	Operator, supervisor and system user	Partner, decision-maker and capacity owner
Sustainability	Important, but often secondary	Integrated strategic goal
Resilience	Often thought of as operational risk	Explicit capability & performance objective

Dimension	Industry 4.0	Industry 5.0
Management accounting	Cost, budgeting and operational control	Cost, investment, risk, sustainability and strategic value management

This comparison is illustrative of the inadequacy of conventional financial reporting. Management accounting in Industry 5.0 has to link financial results with operational, human, sustainability and resilience measures.

Digital Technologies and Management Accounting

Technologies such as AI, IIoT, digital twins, cloud and edge computing, blockchain, collaborative robots and extended-reality technologies enable Industry 5.0 (Maddikunta et al., 2022). But their contribution as managers is dependent on the extent to which data are incorporated in planning, costing, control and investment decisions.

1. AI and Machine Learning

AI/ML can help with forecasting, anomaly detection, predictive maintenance and risk analysis. These capabilities support management accountants in rolling forecasts, variance analysis and predictive cost modelling. The question is not only whether AI improves prediction, but whether improved prediction changes decisions and creates measurable value.

2. Industrial IoT

IIoT provides real time info on machines, production volumes, energy use, quality and inventory. This information may improve standard costing, capacity analysis, working-capital management, and operational variance analysis.

3. Digital Twins

Digital twins allow for testing alternative production configurations and investment scenarios before implementation. They are therefore complementary to lifecycle costing, capital budgeting, sensitivity analysis and scenario planning.

4. Cloud and Edge Computing

Architectures based on cloud and edge increase the speed of processing and access to information. They allow decentralised decision making, support rolling forecasts, integrated dashboards and cost to serve analysis.

5. Blockchain

Blockchain can enhance traceability, provenance and control of transactions across supply chains. Management accounting applications include

supplier costing, procurement analysis, and exception-based control.

6. Cobots and AR/VR

Collaborative robots and AR/VR augment workers instead of simply replacing labour. Management accounting should therefore measure productivity, training, safety and capability development impacts as well as direct labour savings. Additionally, Longo et al. (2020) promote value-based and ethical technology engineering in Industry 5.0.

Table 2. Digital technologies and management accounting applications

Technology	Industry 5.0 application	Application of management accounting	Illustrative KPI
AI/ML	Predictive and analytical decision support	Forecasting, variance analysis, risk modelling	Forecast accuracy; decision-cycle time
IIoT	Real-time operational visibility	Standard costing, capacity analysis, working-capital control	OEE; inventory days; cost per unit
Digital twins	Scenario testing and process optimisation	Lifecycle costing, capital budgeting, sensitivity analysis	Scenario NPV; energy/unit; downtime avoided
Cloud/Edge	Timely and scalable information	Rolling forecasts, dashboards, cost-to-serve analysis	Reporting cycle time; data availability
Blockchain	Traceability and transaction assurance	Supplier costing, provenance and control	Traceability level; exception rate
Cobots	Human-machine augmentation	Labour productivity, safety and workforce planning	Output per employee; safety incidents; training hours
AR/VR	Human capability and learning	Training cost analysis, maintenance support	Time to competency; maintenance time

Theoretical Framework

The main contribution of the present article is the following conceptual path:

Digital Technologies → Industry 5.0 Capabilities → Management Accounting Information and Decision → Enterprise Value

Digital technologies offer data and computational power. These capabilities underpin Industry 5.0 outcomes such as human-centricity, sustainability, resilience, agility and transparency. The results are

then translated into costs, budgets, forecasts, KPIs, investment appraisals and strategic decisions by management accounting. Those decisions impact revenue growth, margins, capital efficiency, risk and long-term enterprise value.

This relation can be written as:

EV = f(revenue growth, operating margin, invested capital efficiency, risk, resilience, human capability, sustainability)

The usual discounted-cash-flow relation holds:

$EV = \sum [FCF^t / (1 + WACC)^t] + \text{Terminal Value}$

The framework thus is not a substitute for measurement of financial value. Instead, it identifies the operational and strategic drivers through which Industry 5.0 capabilities ultimately create financial value.

Fig. 1. Theoretical perspective

Digital Technologies



AI/ML | IIoT | Digital Twins | Cloud/Edge |
Blockchain | Cobots | AR/VR



Industry 5.0 Skills

Human-centricity | Sustainability | Resilience |
Agility | Transparency



Managerial Accounting

Costing | Budgeting | Forecasting | Measurement
of KPIs | Risk analysis | Investment appraisal



Managerial discretion

Cost, Capacity, Workforce, Sustainability, Risk,
Capital Allocation



Firm Value

Revenue growth | Margin | Capital efficiency |
Risk reduction | Resilience | Long term value

Strengthening the Management Accounting Function

Industry 5.0 demands that management accounting moves beyond historical reporting. With activity based costing (ABC) it is possible to determine the resource consumption and profitability of products, customers and processes (Cooper & Kaplan, 1991). Product cost is targeted to meet customer value (target costing) and includes development, production, maintenance and disposal costs (lifecycle costing). In volatile environments rolling forecasts allow continuous planning and scenario analysis gives managers the ability to assess alternative technology and resilience options.

Relevant costing and throughput analysis may be useful for short term capacity decisions. The Balanced Scorecard provides a multidimensional performance architecture, beyond solely financial outcomes (Kaplan & Norton, 1992).

Therefore, management accountants are becoming more engaged in three activities: transforming

operational data into economic information, designing integrated performance systems, and assessing technology investments.

Literature Support

The recent literature indicates a fundamental change of the role of management accounting from traditional reporting and cost control to real-time decision support, strategic analysis and integrated performance management as a consequence of the digital transformation. Bhimani and Willcocks (2014) argue that the nature and use of accounting information is being transformed by digitisation and big data, which is increasing the volume, speed and variety of information available to managers. Similarly, Rikhardsson and Yigitbasioglu (2018) refer to business intelligence and analytics as important developments for management accounting, especially when decision support, performance management and forecasting. Appelbaum et al. (2017) also show how business analytics and enterprise systems can enhance managerial accounting by enhancing the analysis of operational and financial information. Möller, Schäffer and Verbeeten (2020) note that management accounting and control is being disrupted by digitalisation, with a need for new approaches to data, analysis and organisational decisions. Recent research also points to changes in the management accountant's role. Technology is having an increasing impact on managerial decision-making, organisational structures and the balance between human and algorithmic judgement. The transformation is more extensive within the Industry 5.0 context as technology is expected to not only boost productivity but also foster human-centricity, sustainability and resilience (European Commission, 2021; Leng et al., 2022; Ghobakhloo et al., 2024). Specifically, Ghobakhloo et al. (2024) argue that digital capabilities should focus on human-centred, sustainable and resilient production instead of efficiency alone. Hence, management accounting can play a critical translation role in translating digital and operational information into costs, forecasts, KPIs, investment appraisals and strategic decisions that link Industry 5.0 capabilities with enterprise value.

Industry 5.0 Management Accounting KPI Framework

An integrated KPI system is an important requirement. Financial measures continue to

be important but need to be complemented by operational, human, sustainability, resilience, digital and governance indicators.

Table 3. Industry 5.0 Management Accounting KPI Model

Dimension	KPI Example	Calculation	Decision Use
Financial value	NPV, EVA, operating cash-flow improvement, cost-to-serve	Discounted cash flows, NOPAT - capital charge	Investment and value decisions
Operational excellence	OEE; cost per good unit; forecast accuracy; downtime avoided	Availability × performance × quality	Capacity and process decisions
Human-centricity	Training hours per employee; time to competency; safety incident rate; employee adoption rate	Training hours/employee; incidents per hours worked	Workforce and capability decisions
Sustainability	Energy intensity; emissions intensity; material waste rate; water intensity	Resource use/output	Sustainability and cost decisions
Resilience	Mean recovery time; % critical suppliers covered; readiness to recover; revenue at risk	Recovery time; % critical suppliers covered	Decisions on risk and continuity
Digital capability	Data availability, system integration rate, automation rate and model performance	Available records/required records	Digital investment decisions
Governance	Exception rate; cyber incidents; data quality score; responsible AI compliance	Exceptions / transactions; compliance rate	Control and assurance

Appraisal of Technology Investment

Technology investment appraisal should be a central part of management accounting in Industry 5.0. The payback period or accounting return alone should not be used to make investment decisions. The appraisal should consider lifecycle cost, incremental cashflows, risk, strategic fit and non-financial outcomes.

Eight stages are suggested:

1. **Strategic fit** – assess how well it fits with the objectives of Industry 5.0.
2. **Baseline** – determine current costs, performance and risk.
3. **Lifecycle Cost** – including acquisition, implementation, training, maintenance, integration and disposal costs.
4. **Incremental benefits** – find additional

revenue, cost savings, capacity, quality and avoided losses.

5. **Financial assessment** – use NPV, IRR, profitability index and relevant cash flows.
6. **Risk analysis** – sensitivity and scenario analyses.
7. **Non-financial appraisal** – human, sustainability and resilience impacts assessed.
8. **Post investment review** – compare actual results with initial business case.

For example, an investment of Rs.10 million with cash inflows of Rs.3.0 million, Rs.3.5 million, Rs.4.0 million, Rs.4.0 million and Rs.3.5 million for five years. The investment generates a positive NPV of approximately ₹2.84 million with a discount rate of 12%, suggesting financial viability subject to risk and execution assumptions.

So the Industry 5.0 investment rule is:

Financial viability + Strategic fit + Human impact + Sustainability impact + Resilience impact + Governance acceptability

Linkage of KPI to Value Driver

KPIs should not be a reporting exercise. Each indicator should have a clear decision purpose and value driver.

Table 4. KPI to Value Driver Mapping

KPI group	Value driver	Impact on enterprise value
OEE, downtime, throughput	Usable capacity	Revenue growth and operating margin
Cost per good unit	ABC cost-to-serve	Enhanced cost visibility, margin improvement
Forecast accuracy, Days in inventory	Lower inventory and volatility	Working-capital efficiency
Training and adoption	Speed up capability development	Productivity & retention
Energy and material intensity	Reduced resource consumption	Operational savings and sustainability positioning
Recovery time and supplier coverage	Less exposure to disruption	Lower expected losses and risk
Data Quality and Integration	More certainty of decisions	Less risk of decisions and faster response
NPV, EVA	Capital discipline	Investment efficiency and value creation

The management process should be a closed cycle:

Measure → Analyse → Decide → Implement → Review → Update Assumptions → Measure

Strategic Implementation Roadmap

Table 5. Strategic roadmap

Phase	Time	Key Actions	Role of Management Accounting	Expected Outcome
Phase 0	0-6 months	Digital and organisational readiness assessment; baseline KPIs	Establish baseline costs, risks and value drivers	Prioritised business cases
Pilot	6-18 months	Small-scale AI, IIoT, digital-twin or cobot projects	Investment appraisal and benefit tracking	Proof of value
Scale	18-36 months	Integrate systems and expand successful use cases	Rolling forecasts, ABC, KPI governance	Enterprise capability

Phase	Time	Key Actions	Role of Management Accounting	Expected Outcome
Continuous improvement & cross functional integration	36+ months	Optimise	Post-investment review & strategic performance management	Sustainable value creation

Regulation and Challenges

There are a number of risks that may dilute the link between digital capability and enterprise value. Forecasts and KPIs are only as good as the data behind them. Cybersecurity and privacy risks can result in financial and reputational losses. Resistance from the workforce can block anticipated productivity gains. AI models may also introduce bias, opacity or model risk. Total ownership costs can be increased by technology lock-in and short technology lifecycles.

Governance should therefore provide clear data ownership, model accountability, cyber security controls, exception reporting and periodic technology reviews. Responsible technology design is particularly relevant because Industry 5.0 explicitly incorporates humans and societal outcomes in the value equation (Longo et al., 2020).

Discussion and Research Propositions

The framework implies that adoption of technology alone will not result in sustainable enterprise value. Value depends on the org capabilities enabled by technology and on management's ability to translate these capabilities into decisions.

- ⊙ **Proposition 1:** Digital technology creates higher enterprise value when it is transformed into measurable Industry 5.0 capabilities and connected to managerial decisions.
- ⊙ **Proposition 2:** Financial measures alone are not a comprehensive enough basis for managing the performance of Industry 5.0, but integrated financial, operational, human, sustainability and resilience indicators are.
- ⊙ **Proposition 3:** Combining NPV, sensitivity analysis, and non-financial strategic criteria leads to more robust technology investment decisions than relying solely on payback or accounting returns.

- ⊙ **Proposition 4:** The value of real time digital information is dependent on the quality of the data and the accountability and ability of the organization to act on that information.
- ⊙ **Proposition 5:** A post-investment review is critical to improve future decisions on technology investments and capital allocation.

Implications for Management Accounting

The framework offers three main implications. First, management accountants act as interpreters of operational data, translating digital data into economically meaningful measures. Secondly, they act as architects of integrated performance systems that connect financial and non-financial KPIs. Third, they are partners in technology investment decisions, evaluating lifecycle costs, benefits, risk and strategic value.

So the job moves from explaining what happened to helping management decide what should happen next.

Summary

Industry 5.0 should be guided as a value creation system, not just a technology program. Its technologies can produce large amounts of operational information and new capabilities, but the value for the enterprise hinges on whether these capabilities are translated into effective management decisions.

The article provides a conceptual framework of the digital technologies → Industry 5.0 capabilities → management accounting → enterprise value, an integrated KPI framework and a technology investment appraisal approach. This is how strengthening management accounting means organisations can assess not only cost and financial returns but also human capability, sustainability, resilience, digital maturity and governance.

The key implication is the growing strategic role of management accountants in Industry 5.0: bridging technology with measurable performance, disciplined investment and long-term enterprise value. **MA**

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Congratulations!!!

Hearliest congratulations to CMA Ramesh Kumar Gochhayat on assuming charge as Director (Finance), IREL (India) Limited, in the presence of the Chairman & Managing Director (CMD), Director (Marketing), Director (Technical) and other senior officials of the Company.

We extend our warmest wishes to CMA Ramesh Kumar Gochhayat for continued success and excellence in this important role and in all his future endeavours.

