# 2.3  Value‑Chain Reconfiguration

Industry 4.0 is recasting the entire value‑creation logic of manufacturing firms, extending well beyond the four walls of the factory to encompass design, sourcing, distribution, service and end‑of‑life recovery. At the core lies the “digital thread”: a persistent, bidirectional data layer that links computer‑aided design files, process parameters, field‑usage telemetry and recycling passports in one contiguous information spine.¹ Once product and process data flow without breaks, activities that were formerly decoupled in time and space become synchronised; engineering changes propagate instantaneously to suppliers, shop‑floor controllers and after‑sales portals, collapsing iteration cycles and reducing the latency between market signal and physical response.

\*\*Upstream design and sourcing.\*\* Generative‑design tools and multi‑physics simulation engines allow engineers to explore hundreds of lightweight geometries in silico before committing to tooling. The resulting parts often require additive manufacturing, a shift that reconfigures sourcing from multi‑tier metal‑cutting networks to digital inventory models in which printable design files travel instead of physical stock.² In parallel, blockchain‑backed traceability platforms record supplier certifications, carbon intensity and ethical provenance at lot or even unit level, creating a verifiable audit trail that meets growing regulatory demands for due diligence.³ Procurement thus moves from periodic price negotiation to continuous risk and sustainability scoring, supported by AI that flags anomalies—such as sudden energy‑use spikes at a smelter—before contractual breaches occur.

\*\*Responsive, reconfigurable production.\*\* Inside the plant, cyber‑physical work cells equipped with collaborative robots and edge AI vision systems can switch between variants without manual re‑tooling, supporting economical lot‑size‑one production.⁴ Material‑handling robots auto‑seed lines based on demand forecasts fed from cloud retail platforms, turning production planning into an event‑driven rather than batch process. Such flexibility blurs the historical divide between make‑to‑stock and make‑to‑order models, enabling hybrid fulfilment strategies where base demand runs on efficient takt lines and late‑stage customisation occurs in flexible finishing cells.

\*\*Downstream distribution and service.\*\* Real‑time connectivity continues beyond shipment: pallets outfitted with IoT trackers broadcast location, shock and temperature data, allowing automated claims and dynamic ETA updates. AI‑enabled demand sensing meshes e‑commerce clickstreams with weather and social‑media sentiment to refine replenishment signals, compressing bullwhip effects across tiers.⁵ At the last mile, additive manufacturing hubs closer to consumption sites substitute overnight freight with point‑of‑need printing, reducing lead time and emissions while shrinking the spare‑parts catalogue. Post‑sale, predictive maintenance algorithms push usage‑condition insights back into design, closing the product–service feedback loop and nudging manufacturers toward outcome‑based revenue models.

\*\*Circularity and end‑of‑life.\*\* The emerging digital product passport (DPP) anchors circular economy objectives by storing material composition, disassembly instructions and residual value indicators in a tamper‑proof ledger that travels with the asset.⁶ Automated dismantling stations equipped with computer‑vision robots read DPP data to identify reclaimable alloys or polymer grades, while ERP systems trigger credit notes for customers who return products. Consequently, value‑chain boundaries extend into reverse logistics and secondary markets, converting waste streams into resource pools and creating new profit pockets in remanufacturing and recycling.

\*\*Organisational implications.\*\* Technological convergence forces functional silos to collapse. Cross‑disciplinary ‘digital operations’ teams own the entire life‑cycle data set, supported by platform governance councils that issue common data taxonomies and API policies. Decision rights migrate downward—machine‑learning agents can reroute trucks or adjust furnace parameters autonomously within guardrails—while human roles shift toward exception handling and capability orchestration. Firms that do not realign incentives around total life‑cycle value risk local optima: engineering may design for manufacturability but ignore end‑of‑life recovery, or sourcing may chase lowest landed cost without regard to traceability compliance. Governance, therefore, becomes a critical success factor in realising full reconfiguration potential.

\*\*Uneven progress and emerging challenges.\*\* Empirical surveys reveal stark dispersion. Leaders achieve double‑digit reductions in engineering change orders and inventory obsolescence within three years of digital‑thread deployment, while laggards struggle with data silos, supplier connectivity gaps and skills shortages that stall transformation.⁷ Moreover, increased cyber‑attack surface, intellectual‑property leakage via shared design files and the carbon footprint of always‑on analytics platforms introduce new trade‑offs, highlighting the need for resilient architecture and green‑by‑design digital infrastructure.

In sum, Industry 4.0 catalyses a shift from linear, function‑segmented value chains to \*\*dynamic, circular value networks\*\* where data continuity, decentralised intelligence and servitised business models redefine how value is created, delivered and captured. The three case companies analysed later in this thesis—each occupying different positions along the value chain—offer contrasting laboratories for observing how these reconfiguration mechanisms unfold in practice and what bottlenecks hinder their full exploitation.

## Footnotes

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