Technological Monopoly and Responsible Innovation

Can ASML's Industrial Dominance Be Aligned with the UN Sustainable Development Goals?

Introduction

The United Nations Sustainable Development Goals (SDGs) position technological innovation at the centre of sustainable global development (United Nations, 2015). SDG 9 (Industry, Innovation and Infrastructure) calls for resilient infrastructure, inclusive industrialisation, and strengthened scientific capability, while SDG 8 (Decent Work and Economic Growth) promotes sustained, inclusive and productivity-enhancing economic development (United Nations, 2015). Within this framework, few firms occupy a more strategically consequential position than ASML Holding N.V., the sole commercial provider of extreme ultraviolet (EUV) lithography systems used in advanced semiconductor manufacturing (ASML, 2023; The Economist, 2021).

By 2030, digital technologies are projected to account for an increasing share of global economic activity (World Economic Forum, 2020). Semiconductor capability forms a foundational layer of this digital economy, underpinning advanced computing systems (SIA, 2022). In this context, governance of upstream semiconductor technologies becomes inseparable from governance of global development trajectories.

ASML is not merely a technology company; it is a structural enabler of global digital infrastructure. Its lithography machines underpin artificial intelligence systems, renewable energy optimisation technologies, medical diagnostics, telecommunications networks and industrial automation (Brynjolfsson and McAfee, 2014; IEA, 2023). Yet this enabling role introduces a paradox. ASML's technological leadership is characterised by extreme concentration of capability. Its monopoly over EUV lithography grants it disproportionate influence over global computing power and industrial capacity (ASML, 2023; Miller, 2022).

This essay argues that ASML materially advances SDG 9.5 while contributing to SDG 8 through high-skilled employment and sustained investment. However, ecosystem dependency, geopolitical entanglement and structural concentration complicate automatic SDG alignment. Frontier innovation advances sustainable development only when technological authority is matched by governance maturity and institutional resilience.

I. Theoretical Framing: Responsible Innovation and Concentrated Power

Responsible business scholarship recognises that innovation cannot be assessed solely through patents or revenue growth. It must be evaluated in terms of systemic impact, resilience and inclusivity (Schaltegger and Burritt, 2018; Stilgoe, Owen and Macnaghten, 2013).

Dynamic capabilities theory emphasises a firm's ability to sense, seize and reconfigure opportunities under uncertainty (Teece, Pisano and Shuen, 1997). Such capabilities generate technological advancement but may also deepen ecosystem dependency. ASML exemplifies this through sustained R&D reinvestment and technological renewal (ASML, 2023). When adaptive success consolidates control over critical industrial nodes, competitive advantage evolves into structural influence.

Open innovation theory suggests that innovation performance depends on breadth and depth of collaboration (Laursen and Salter, 2006; Chesbrough, 2003). Yet excessive concentration of knowledge flows may reduce resilience. This inverted U dynamic is particularly relevant to SDG 9's emphasis on robust infrastructure (United Nations, 2015).

Responsible innovation therefore requires balancing:

- Technological advancement
- Ecosystem resilience
- Distributional inclusivity

ASML's case tests whether these dimensions can coexist within a highly concentrated industrial structure.

II. Advancing SDG 9: Frontier Industrial Capability

ASML advances scientific and technological capability under Target 9.5. EUV lithography enables sub-5nm chip production supporting AI computation, cloud infrastructure, renewable energy optimisation and advanced medical imaging.

Between 2018 and 2023, ASML's revenues more than doubled, reflecting accelerating demand for advanced semiconductor capability (ASML, 2023). EUV system expansion reinforces its position as a single-point enabler of next-generation chip production.

ASML reinvests over 20% of revenue into R&D annually (ASML, 2023). Sustained reinvestment aligns with endogenous growth theory linking technological innovation to long-run productivity expansion (Romer, 1990). This long-term orientation contrasts with short-term financial extraction models.

However, industrial upgrading alone does not fulfil SDG 9. Resilience under Target 9.1 remains equally critical.

III. Ecosystem Dependency and Industrial Fragility

ASML's innovation model is embedded in a specialised ecosystem. Critical optical components are sourced from limited partners, while co-development with TSMC, Intel and Samsung drives product evolution (ASML, 2023; Miller, 2022).

Concentration of inputs increases vulnerability to:

- Geopolitical conflict
- Export controls
- Supply chain disruption
- Regional instability

Recent export restrictions imposed by the Dutch and United States governments illustrate how upstream concentration becomes entangled in national security policy (Bureau of Industry and Security, 2023; Miller, 2022).

From an SDG 9 perspective, resilience requires diversification of industrial dependencies (United Nations, 2015). A system dependent on singular technological nodes risks fragility.

Laursen and Salter's inverted U framework suggests that excessive narrowness in collaboration may constrain adaptability (Laursen and Salter, 2006). Industrial excellence achieved through concentration may therefore reduce systemic robustness.

IV. Monopoly Power and Governance

ASML's EUV monopoly represents rare single-firm technological gatekeeping (ASML, 2023; Miller, 2022). Schumpeterian theory recognises that temporary monopoly profits can incentivise breakthrough innovation (Schumpeter, 1942). Yet responsible development requires evaluation of structural power (Stiglitz, 2019).

Access to EUV lithography is restricted to capital-intensive firms in advanced economies (SIA, 2022). Frontier productivity gains accrue disproportionately to technologically advanced regions.

When industrial capability is geographically concentrated, global divergence may widen (Rodrik, 2018). Concentrated technological authority increases governance demands (Mazzucato, 2013). Where authority is centralised and governance fragmented, systemic instability may emerge.

SDG alignment depends not solely on innovation output but on institutional capacity to manage concentrated power responsibly.

V. SDG 8: Human Capital and Distribution

ASML contributes significantly to high-skilled employment (ASML, 2023). These roles generate knowledge spillovers and support high-value clusters (Porter, 1998).

Sustained R&D investment reinforces productivity growth (Romer, 1990). Yet sustainable growth and inclusive growth differ (United Nations, 2015).

Advanced semiconductor ecosystems require extensive capital, specialised infrastructure, skilled labour and dense supplier networks. These barriers limit participation for emerging economies (Rodrik, 2018; Autor, 2014).

To align more fully with SDG 8, ASML could expand global research partnerships, educational collaboration and digital capability diffusion.

VI. Environmental Sustainability and Lifecycle Integration

Semiconductor manufacturing is energy intensive (IEA, 2023; SIA, 2022). Simultaneously, advanced chips enable decarbonisation across energy systems and industry (IEA, 2023).

Efficiency improvements per chip may reduce energy intensity, yet expanded computation can increase aggregate demand — consistent with rebound dynamics (Sorrell, 2009).

Target 9.4 calls for resource-efficient infrastructure (United Nations, 2015). Environmental metrics must therefore be integrated into R&D stage-gate processes.

Embedding carbon intensity tracking and lifecycle recyclability standards aligns technological performance with long-term sustainability (Bocken et al., 2014).

VII. Organisational Governance and Scaling Risk

ASML’s hybrid innovation structure reflects corporate entrepreneurship capability (Zahra, 1996). As complexity grows, coordination crises may emerge (Greiner, 1972).

Large-scale technological organisations risk:

- Knowledge fragmentation
- Coordination overload
- Reduced agility

Organisational design theory highlights governance challenges in scaling firms (Mintzberg, 1979). Sustainability performance indicators must be embedded structurally (Schaltegger and Burritt, 2018).

Innovation authority requires institutional maturity, particularly where corporate decisions carry macroeconomic consequences (United Nations, 2015).

VIII. Strategic Pathways Toward Stronger Alignment

To deepen SDG alignment, ASML should:

- Diversify critical supplier relationships
- Integrate environmental metrics into R&D gates
- Expand global educational partnerships
- Increase geopolitical risk transparency
- Formalise ecosystem stewardship principles

These measures reposition technological dominance within resilient institutional frameworks.

XI. Industrial Geography and Structural Inequality

Semiconductor manufacturing is concentrated in East Asia, the United States and Europe. Clustering benefits high-technology industries through knowledge spillovers (Porter, 1998).

However, extreme clustering reinforced by proprietary upstream technologies may entrench global stratification. Semiconductor capability increasingly shapes economic sovereignty.

Responsible leadership may involve supporting educational pipelines and facilitating adjacent ecosystem development.

XIV. Counterargument

A counterargument holds that ASML's innovation contribution outweighs concentration concerns. Schumpeterian theory suggests monopoly rents sustain breakthrough innovation (Schumpeter, 1942). EUV lithography requires sustained co-investment and expertise few firms could replicate.

Forced diffusion could slow innovation in renewable energy, electric vehicles and medical diagnostics. However, responsible development requires balancing innovation speed with structural stability.

XV. Synthesis

SDG alignment is conditional rather than automatic (United Nations, 2015). Frontier innovation accelerates industrial upgrading yet introduces structural risk.

Alignment depends on ecosystem diversification, diffusion of productivity gains, lifecycle environmental integration and governance proportional to monopoly power.

ASML represents a test of whether industrial governance can evolve alongside technological scale.

Conclusion

ASML advances SDG 9 and supports SDG 8 through sustained innovation and high-skilled employment. Yet structural dominance introduces proportional obligations.

Technological progress alone does not guarantee sustainable development. Governance of concentrated power is equally decisive.

Sustainable development in the twenty-first century will be shaped not only by innovation speed, but by institutional stewardship.