Building *and* Sustaining
Innovation Under Uncertainty

LESSONS LEARNED FROM ASML

SUSANNE VAN DER VELDEN
MOHAMMAD NASIR NASIRI

Lannoo
Campus

CONTENTS

CHAPTER 1

SETTING THE SCENE

"But few investors would have bet their money on this venture today. The story of ASML and its product 'the stepper' is therefore not a recipe that can be easily copied by other 'high-tech start-ups', which doesn't mean that nothing can be learned from looking at what happened."

GJALT SMIT, FIRST CEO

OPENING

ASML began as a small joint venture on the outskirts of Eindhoven. Few outsiders would have predicted that this modest start would grow into a company whose machines sit at the heart of the digital world. Yet over four decades, ASML moved from repeated vulnerability to a position where its technology helps set the pace of progress in the semiconductor industry and subsequently the progress in developing increasingly advanced technologies.

That rise is easy to misinterpret if told as a simple success story. ASML's path was shaped by moments when survival was uncertain, when bets had to be placed before outcomes were knowable, and when the company's future depended on choices made under pressure. Those choices accumulated over time. They left imprints in routines, relationships, and ways of organizing that became decisive again and again as the environment changed.

This book treats ASML's journey as a grounded case study to spur thinking about innovation in complex settings, for ourselves and hopefully for you as well. Our aim is to understand how long-term innovativeness can be built and sustained when uncertainty is structural and when technology, capital, and interdependence move together. The chapters that follow reconstruct the episodes we studied most closely and translate what they reveal into lessons for leaders who face long horizons, high stakes, and limited room for error.

ASML IN A NUTSHELL

When ASM Lithography opened its doors on 1 April 1984, its 47 employees worked partly out of two wooden barracks at the edge of the Philips campus in Eindhoven. Four decades later, that spin-out has become Europe's largest technology company and a central supplier in the global semiconductor industry.

> THE ENGINEERS AND OPERATIONS PEOPLE WERE HOUSED IN THE PHILIPS OFFICES WHILST THE SUPPORT ORGANIZATION, THE CEO, MARKETING, HR AND FINANCE WERE IN THE BARRACKS, SIGNALING A LOW KEY ATTITUDE FOR A LOSS MAKING START-UP

From early on, ASML developed as an orchestrator rather than a fully integrated manufacturer. Over time, it built a network of thousands of specialized suppliers that contribute critical components, from optics and light sources to ultra-precision mechanics. ASML defines the system architecture and performance specifications; partners manufacture and deliver the parts. This distributed structure did not emerge overnight. It evolved alongside the increasing complexity of the machines and now allows the company to scale while keeping design authority and coordination concentrated at the center.

Running through this structure is a persistent commitment to research and development. Across cycles, management has reinvested a substantial share of annual revenue into new platforms. During downturns, when industry demand contracted sharply and competitors reduced spending, ASML continued to fund long-term programs. This discipline meant that when markets recovered, new generations of machines were ready. Over time, that approach contributed to a record of delivering successive platforms broadly in line with industry roadmaps.

These organizational and investment choices positioned ASML at the technical frontier of lithography. Its products now sit at a fundamental bottleneck in the semiconductor industry. Modern processors depend on patterns narrower than a virus, and lithography determines how small those features can be. For the most advanced chips, ASML has become the only company that ships extreme-ultraviolet scanners. That position carries both leverage and responsibility. Because customers build their own roadmaps around the timely arrival of new machine generations, a delay of even one technology node can cascade through the wider industry and world economy.

The economic stakes mirror the technical ones. A limited number of systems generate tens of billions of euros in annual revenue, and each new platform represents a long-term commitment of capital and engineering effort. At the same time, the semiconductor industry remains sharply cyclical. Periods of heavy investment are followed by abrupt contractions, during which orders can decline far faster than development programs can be halted. Strategic decisions about platforms, partnerships and capacity are therefore made under persistent tension between technological ambition and financial risk. Today, ASML's footprint extends beyond technology alone. Because supply at the most advanced frontier is effectively single-sourced, export licenses and capacity decisions appear in industrial strategies and geopolitical debates. Scale has brought visibility and influence, but also heightened interdependence and exposure.

Against that backdrop, a few numbers help to anchor the scale of ASML's operations:

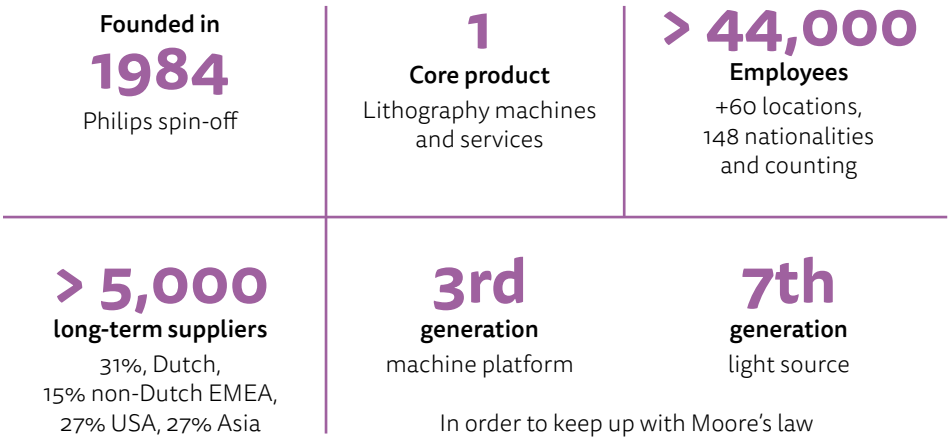

Figure 1.1 Size of ASML.

Engineering on the edge

- **15% of revenue for R&D:** on average over the last decade during the crises years this percentage rises: 1990: 29%, 2001: 19%, 2009: 29%.
- **> 33,000 patents in portfolio;** a portfolio that is both large and influential. Roughly 1 in 40 rejections of patent applications in the US is based on ASML's prior right to technology.
- **2 nanometer transistor lines** can be produced by a High NA EUV machine. To put this in perspective, grass grows about 2–6 cm/week or 30–100 nm per second. The high NA printing capability of around 10 nm is equal to growth of grass in 0.1 second.
- **< 0,02 nm** is the maximum deviation on an EUV mirror. If you scale an EUV mirror surface to the size of Brabant (5,000 km^2), you end up with a 10 cm sidewalk bump on the entire surface.

Staying one node ahead

100%
market share for the most advanced tools
>90% of the value capture in the overall lithography market

25,1%
net margin
On average over the past 10 years

€28,3B
revenue
In 2024, on average a 17,5% yearly turnover growth over the past decade. Target revenue 2030: €44–€60B.

>$300
market cap
One of the top 40 most valuable companies worldwide

Figure 1.2 Key characteristics.

Year	Revenue	# Shipped machines
1984	€530.000	1
1994	€242.730.000	107
2004	€2.465.000.000	282
2014	€5.856.300.000	136
2024	€28.300.000.000	583

Table 1.1 Revenue and machines.

WHY ASML MATTERS NOW

ASML's current position did not emerge from a single breakthrough or a brief period of advantage. It is the result of choices made across decades in an industry defined by extreme capital intensity, rapid technological transitions, and recurring cycles of expansion and contraction. Platform shifts, ecosystem realignments, and downturns forced the company to commit resources long before outcomes were certain. Each commitment narrowed some options while opening others, shaping what became possible in later generations.

That accumulated path is what makes ASML instructive today. Many organizations operate under comparable conditions. Investment horizons are lengthening, dependence on specialized partners is deepening, and political or economic volatility can alter market conditions with little warning. The challenge is no longer simply to innovate successfully once, but to remain inventive across successive waves of change. ASML makes that challenge visible because its history spans multiple technology generations and leadership eras. It shows how organizational architecture, ecosystem design and investment discipline interact over time. By examining selected episodes in detail, this book seeks to clarify how long-term innovativeness can be sustained when uncertainty is structural rather than temporary.

WHAT KIND OF BOOK THIS IS

This book takes a deliberate and selective approach. It does not aim to be a complete canon of ASML's technical and organizational development, and it was never meant to. Chapter 2 offers the forty-year arc and the key transitions; from there, we zoom in on a limited set of episodes that show how the organization responded to uncertainty, competition, and scale over time, because those moments make the underlying logic visible. That selectivity is intentional: by staying close to decisive moments, recurring patterns emerge, mechanisms that can help readers make sense of innovation beyond ASML as well. Inevitably, this also means that other important developments remain off-stage. That is not a judgment on their value; it is a choice in service of clarity, so we can understand a few moments well enough that they become genuinely useful.

The material draws on extensive research, including archival sources, performance data, and interviews with current and former executives. That foundation informs the analysis, yet the purpose of this book is practical. The emphasis lies on decisions, trade-offs, and consequences – on how choices were framed, committed to, and carried forward – rather than on theoretical debate. However, we do use theoretical perspectives in order to make the insights from ASML's highly specific conditions transferable to other contexts. We reconstruct moments when the future was unclear: crises, platform transitions, shifts in ecosystem structure, and phases of apparent dominance. In each case, managers had to act without knowing how technologies, markets or politics would evolve. By examining those situations closely, broader themes emerge. How do you pace large technological bets? How do you structure partnerships without losing strategic control? How do you preserve flexibility while committing significant resources? How do you maintain urgency when success appears secure?

ASML's history is presented here as a case that sharpens thinking. The frameworks introduced later in the book serve to organize observation and reflection. They are tools for interpretation, instead of formulas to copy. The aim is to make visible how long-term innovativeness is built and renewed, and to offer readers a structured way of examining their own strategic context.

WHO THIS BOOK IS FOR

We wrote this book primarily for leaders and decision-makers who operate in environments shaped by technological uncertainty and long investment horizons. That group includes managers in innovative organizations who must deliver today while preparing for the next wave of ideas; founders and executives in deep-tech ventures navigating long development cycles and irregular demand; and corporate leaders in established firms seeking to renew a mature business without destabilizing its core.

It also includes policymakers who design industrial and innovation policies in economies where a small number of firms can carry disproportionate strategic weight. In such settings, understanding how capabilities accumulate – and how ecosystems evolve – becomes more than a corporate concern. Although these contexts differ, the underlying challenge is similar: how to commit resources under uncertainty

while preserving the capacity to adapt by organizing for ongoing learning and innovation. In Chapter 9, we return to these groups explicitly and connect the lessons from ASML's journey to their distinct concerns.

Other readers may find their own reasons to engage with this story. Engineers may recognize familiar trade-offs in platform design and supplier coordination. Students and teachers may use the case to connect theory and practice. Regional planners may see reflections of their own dilemmas in the interaction between corporate growth and local ecosystems. The invitation is open, but the core audience remains those responsible for making long-term decisions under uncertainty.

HOW THIS BOOK WAS MADE

A long-gestating idea. The idea to study ASML in depth emerged long before the company became a geopolitical reference point. More than twenty years ago, a group of retired managers began documenting what they called the "business equations" that had helped the young firm survive its early crises. Among them was Susanne's mother, who had worked at ASML from its early years and preserved her own archive of documents, notes and reflections. Some of that material fed into the 2004 anniversary volume Reflect & Imagine, but the more analytical drafts were never published. The boxes were stored away while the company continued to evolve.

Almost a decade later, we reopened them. By then, both of us were working on doctoral research in strategic innovation and related fields. ASML offered an unusually rich setting for examining questions that extend beyond one company: how to commit to long-horizon research when markets and policies can shift abruptly; how to distinguish between crises that require immediate action and risks that quietly erode future options; how early design decisions shape later strategic possibilities.

Evidence over ego. Over more than ten years, we combined archival work, internal and public documents, longitudinal performance data and in-depth interviews with current and former executives. We reconstructed key decisions, traced how strategies evolved across downturns and expansions, and compared recollections with documented records. Our guiding principle throughout was straightforward: when the evidence challenged a neat narrative, the narrative had to change.

This long view revealed more than a sequence of products or crises. It showed how certain patterns recurred at decisive moments: simple rules that anchored direction without freezing adaptation; platform choices that preserved future options; ways of working with key partners that balanced collaboration and control; organizational arrangements that absorbed tension between technological ambition and economic constraint. These recurring elements form the backbone of the lessons developed in this book.

From dissertation to desk tool. The research initially served academic purposes. The dissertations have been defended, and scholarly work continues. Over time, however, a different request emerged. Executives in workshops, policymakers in advisory settings, and participants in our classrooms repeatedly asked how these insights could be translated into guidance for practice.

We hesitated. The market is saturated with management books that promise clarity and deliver oversimplification, and we had little appetite for adding another neat story to a messy world. What ultimately persuaded us was more personal and more practical: when we face unfamiliar situations ourselves, we also reach for carefully researched case studies—as inspiration to spur our own thinking process. ASML's journey, precisely because it is path-dependent and context-specific, provides a disciplined way to ignite thoughts about questions that arise far beyond lithography: how to organize for both growth and ongoing organizational flexibility, how to pace large commitments, how to structure partnerships without surrendering strategic position, how to maintain direction when immediate pressures accumulate.

This book is our attempt to make that material accessible without diluting it. We stay close to what the evidence allows, name uncertainties when they cannot be resolved, and resist the temptation to turn hard-won experience into a tidy recipe. The frameworks in later chapters are there to structure attention: to help you notice patterns, test assumptions, and ask better questions. If the book succeeds, it increases your awareness about what matters when you are building, protecting, and renewing long-term innovativeness.

A MAP OF THE BOOK – AND HOW TO READ IT

There is more than one way to move through this book, but it helps to see the overall structure before you begin. Figure 1.3 offers a visual overview. Each chapter draws on a set of perspectives developed in our research – perspectives that help organize observations around a central question: how can long-term innovativeness be built and sustained under uncertainty?

The book unfolds in two broad movements. Chapters 2 to 6 address the question "What happened?" Chapter 2 presents ASML's overall trajectory in condensed form. Chapters 3 to 6 then revisit that trajectory through a number of recurring themes: the business equations that shaped strategic focus, the way collective uncertainty was handled within the semiconductor ecosystem, the role of options and portfolios in navigating technological regime shifts, and the interplay of preparation and contingency when crises and opportunities arose. Together, these chapters trace how a vulnerable spin-out evolved into a cornerstone company in a concentrated and volatile industry.

The second movement steps back from the narrative. Chapter 7 translates the main perspectives into broader concepts of capabilities, routines, ecosystems, and strategic commitments. Chapter 8 reflects on what our years of research and practice in uncertain innovation environments have revealed to us about organizational decision-making. Chapter 9 returns to the groups introduced earlier and connects lessons from ASML's journey to their distinct strategic concerns. Chapter 10 closes the argument, outlines limitations, and points readers toward further work.

Although the book is structured sequentially, it need not be read that way. Readers primarily interested in conceptual frameworks may begin with Chapter 7 and return to the story later. Those drawn to practical implications may turn directly to Chapter 9. Whatever path you choose, the intention remains the same: to use a deeply examined case to clarify how organizations can act deliberately under conditions they cannot fully control. There are no miracle cures here, nor any promise that following ASML's path will produce a BSML, CSML or DSML. Instead, we offer a disciplined case examined through research and practice, intended to sharpen how you think about long-term commitments, uncertainty and strategic design.

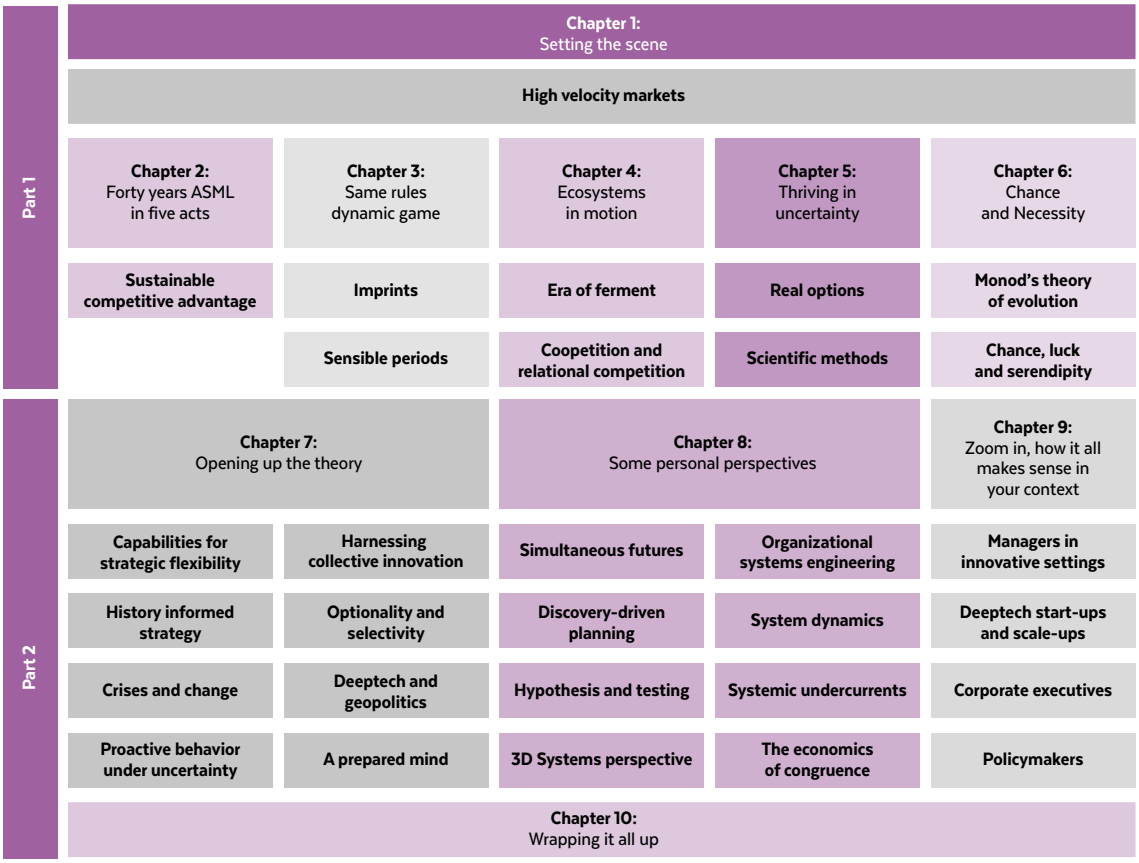

Figure 1.3 Book outline.