SEPTEMBER 2025

The Netherlands' Innovation Landscape

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A Report of CSIS Renewing American Innovation

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Introduction

In a world that runs on advanced technologies and where the competition to lead in these technologies is intense and distributed around the world, a robust innovation system is a national security imperative. In this fiercely competitive environment, the Netherlands has developed a pragmatic strategy that develops its research and development infrastructure, leverages its leadership in advanced semiconductor technologies, and builds new global networks for cooperation.

A nation of 18 million people, the Netherlands has long exercised outsized influence within the European Union, the international community, and the global high-technology ecosystem. This influence is built on the excellence of the country's technical universities and numerous research organizations, as well as on the dynamism of its large and small companies. These assets are arguably reinforced by the liberal, cosmopolitan character of Dutch society and the country's centuries-old collaborative innovation culture.

This strategy of reinforcing Dutch exceptionalism has been manifested most recently in response to the global semiconductor shortage during the Covid-19 pandemic and can be seen in the recent measures taken to counterbalance China's emergence as a strategic and technological rival to the United States and its allies, including the Netherlands.

A Strategic Advantage in Semiconductors

The pandemic-related chip shortage and growing Chinese technological prowess have focused U.S. policymakers on the need both to establish a secure onshore production base and to build

robust supply chains for semiconductors. In parallel, U.S. policymakers have sought to deprive China of the tools needed to make the most advanced semiconductor devices—the 3, 2, and below nanometer (nm) devices needed to achieve and maintain leadership in artificial intelligence (AI) and advanced weapon systems.

To achieve these pressing national goals, U.S. policymakers quickly realized that both objectives require close collaboration with Netherlands-based ASML, the only company in the world capable of making the extreme ultraviolet (EUV) lithography equipment needed to produce chips with 3 and 2 nm line widths—machines often described as "the most complex machine[s] on earth."[1]

Chips made with ASML machines are necessary to enable advanced AI, which could be determinative in commercial competition, or even a conflict, between China and the United States and its allies. At present, deprived of access to the most advanced ASML EUV machines by U.S. and EU export controls, China is unable to produce the best-performing devices to support advanced AI over the short and medium term, though the country is making undeniable progress in developing its own advanced chips.

By contrast, firms investing in new chip fabs in the United States, Taiwan, South Korea, Europe, and Japan are installing the cutting-edge ASML lithography equipment and will be able to mass produce 3, 2, and below nanometer devices within the coming months and years. In fact, Taiwan is doing so already. These faster, more powerful chips are key to opening new opportunities in research, education, health, and security.

In short, ASML—a Dutch company developed through great effort over many years—holds the key to the strategic balance between the world's two greatest powers and their respective allies.

The Netherlands Is Seeking to Create New Leverage

Recognizing the technological, commercial, and ultimately political advantages of the Dutch position in semiconductor manufacturing, the Dutch government's National Technology Strategy (NTS), released in 2024, explicitly states the objective of replicating ASML's success in other key sectors. Arnaud de Jong, managing director of the Netherlands Organisation for Applied Scientific Research (TNO)—the largest research organization in the Netherlands and a key contributor to the NTS—observed that the "Netherlands needs to conquer more key positions in value chains . . . We must have the ambition to produce a handful of new ASMLs. By that I don't necessarily mean companies the size of ASML, but companies that no company or country can ignore in a particular industry."[2]

In pursuit of this goal, Dutch policymakers are seeking to create entities and programs to replicate the factors that led to ASML's eventual success, particularly the local ecosystem that enabled the company to survive and succeed in spectacular fashion over a decades-long time horizon.[3]

ASML is perhaps the foremost example of a company that has successfully developed so-called deep-tech innovations. Deep-tech ventures usually involve complex and expensive hardware

innovation, and thus are sharply distinguished from software ventures, which are relatively quick to develop and offer opportunities for substantial returns in a shorter timeframe.

Given their sheer complexity and capital needs, deep-tech enterprises face a "valley of death" that is unusually deep and long, and experience extremely high failure rates, possibly above 90 percent. Time to market is typically five to seven years but can be much longer.[4] Thus, creating more ASMLs requires the possession of potentially transformational technologies, formidable resources and expertise, and acceptance of long time horizons and high probability of failure.

Private investors are normally not willing or able to undertake such investments at scale amid the attendant risks. The Netherlands, however, has succeeded in the past and, more recently, has made a commitment as a nation to building the programs and institutions needed to make the NTS vision a reality.

A 2024 study by TechLeap, a nonprofit funded by the Dutch Ministry of Economic Affairs and Climate, observed that the Netherlands has enjoyed stable investment in deep-tech in recent years, "bucking the trend of year-on-year tech investment decline from 2021."[5]

Particularly promising is Deep Tech XL in Eindhoven, a venture-builder founded by Guus Frericks, a former Philips industrial engineer who closely studied the evolution of ASML and is applying the lessons learned to launch new deep-tech ventures in the community from which ASML arose (see the section on Brainport Eindhoven below). Deep Tech XL is already rated as one of the five best organizations of its kind in the world.[6]

In 2022, the €250 million Deep Fund NL was launched by the Ministry of Economic Affairs and Climate, which put in €175 million, and Invest-NL, which provided the remainder. The fund is intended to support deep-tech long-term investments with high potential in fields such as microelectronics, photonics, quantum technology, medical technology, advanced materials, and nanotechnology.[7]

The National Technology Strategy

Over time, successive Dutch governments have progressively narrowed their innovation policy goals to avoid dispersal of resources and effort. The current policy focus, embodied in the NTS, is on 10 strategic-priority technologies in which the Netherlands may be able to dominate essential technological capabilities to possibly replicate ASML's achievements.

In 2019, the Dutch government introduced the concept of "mission-driven top sectors," a form of industrial policy focused on applying scientific research, innovation, and education in four key areas of national concern: healthcare, energy, security, and agriculture.[8] Together, representatives from the government, industry, academia, and the public—referred to as "the quadruple helix"—identified 25 "missions" for coordinated developmental efforts within the four areas of concern.[9] To facilitate this effort, the government and the country's largest research organization, TNO, jointly identified 44 key enabling technologies (KETs) relevant to this effort as the focus for government, industry, and academic developmental efforts.[10]

In 2024, the Dutch government adopted the National Technology Strategy (NTS) drafted by the Ministry of Economic Affairs and Climate. The NTS singles out 10 of the 44 KETs as strategic priorities for companies, government agencies, knowledge institutions, and social organizations. The NTS states that "[W]e must make choices. The Netherlands cannot lead the way in all areas. We are too small for that. . . . As a small country, we must also identify the technological niches, or combinations thereof, where we can lead the world."[11] The 10 technologies are as follows:[12]

- Optics and integrated photonics
- Quantum technology

- Green chemical production processes
- Biotechnology, particularly at the molecular and cellular levels
- Imaging
- (Opto) mechatronics, which includes industrial systems, machines, and equipment
- AI and data science
- Energy materials
- Semiconductors
- Cybersecurity

The 2024 NTS establishes a separate roadmap for each technology and specifies the targets to be achieved by 2035. By design, the 10 technology areas are interrelated and mutually reinforcing; progress in one can help to drive progress in others. In this respect, the NTS resembles China's highly successful Made in China 2025 effort, and is built along the same lines.[13]

Each technology area was selected based on the realistic prospect that, given certain existing strengths, the Netherlands can achieve a key position internationally similar to that which ASML has gained within the semiconductor industry, so that global players will have no commercially viable choice other than integrating Dutch actors into strategic points in their value chains.[14]

Despite the country's small size, the Netherlands is home to almost the entire semiconductor value chain, which can be said of only a handful of countries, almost all of them larger.

The technology areas are well chosen, with the country already enjoying substantial depth in these 10 areas. Capturing this approach, a spokesperson for one of these sectors observed that "in the Netherlands, we do what we are [already] good at."[15] In integrated photonics, for example, the country currently has 300 companies and 5 regional innovation clusters pursuing various photonics technology themes, with the country as a whole comprising "a single, coherent, and well-synchronized Photonics region."[16]

Despite the country's small size, the Netherlands is home to almost the entire semiconductor value chain, which can be said of only a handful of countries, almost all of them larger.[17] The Netherlands is already a world leader in the production of ultra-complex high-technology equipment, including medical instruments, data communications, and manufacturing systems, an advantage that will support efforts in all 10 strategic priority areas.[18]

Challenges Facing the Netherlands in Innovation

While the Netherlands is one of the most innovative countries in the world, innovation policymakers and industry leaders are sounding the alarm that the country is not doing enough

to remain competitive internationally. Current challenges include growing antipathy to migrants (including crucial technology sector workers) by a number of Dutch political parties; inadequate public funding; resource constraints such as housing and power supply in innovation centers; and burdensome government regulation at both the national and EU levels. These concerns are valid and are currently being highlighted in policy discussions and reports assessing the Dutch innovation ecosystem.

In April 2025, TNO published a study sharply critical of the current state of Dutch innovation, observing that, though the Netherlands enjoyed an excellent basic science base, it was not sufficiently successful in converting scientific discoveries into practical applications. It warned that technology-intensive Dutch companies were relocating outside of the Netherlands due to a deteriorating domestic investment climate, and that the country was not doing enough to enable startups to grow.[19]

In September 2024, an EU-sponsored study headed by Mario Draghi, former head of the European Investment Bank, made sweeping recommendations for enhancing Europe's innovation capabilities and strategic independence, including annual outlays of €800 billion.[20] The Draghi Report sparked a debate among Dutch political leaders in which government budget hawks' calls for deep cuts clashed with the technology sector's need for increased funding. One official remarked that "Draghi's report and our current cabinet seem like two different worlds,"[21] no doubt reflecting the traditional Dutch focus on maintaining close control of government expenditure, even in the face of the emergence of a dramatically more competitive, more insecure, and more uncertain international environment.

Perhaps reflecting this lack of focus on innovation, ASML has complained for years that the central and local authorities are not doing enough to support its substantial infrastructure and workforce needs, going so far as to warn in 2024 that it was considering undertaking its planned future expansion investments outside of the Netherlands. ASML is concerned about regulatory impediments to expansion and prospective restrictions on foreign students and knowledge workers. Maintaining ASML's investments in the Eindhoven cluster is widely recognized to be an essential element in the continued growth of the Dutch high-tech ecosystem and one deserving of internationally competitive support. However, the current political environment is complex. The limited mandate of the current central government raises questions about its ability to address the nation's innovation challenges in a decisive manner in the near term.

Nonetheless, despite these political uncertainties, the country's decentralized and highly successful innovation system remains robust and active as one of the most successful in Europe, and indeed the world.

The Network Governance Approach

The Dutch approach to industrial and economic development policy has been characterized as a form of "network governance," in which government agencies relinquish some of their authority to private companies, research organizations, and other nongovernmental actors that are then

grouped into public-private arrangements in which major stakeholders expect to participate in the shaping of policy. Government agencies seek to steer rather than regulate or command the direction of policy, using tools such as consensus building and allocation of resources to guide research to areas it sees as priorities. As some scholars describe, "the state's role shifts from instigator to mediator of stakeholder networks." Those networks reflect the country's longstanding cultural tradition—the so-called "polder model," a form of cooperation-despite-differences in which "major stakeholders [both public and private] are involved in many policy-making decisions in many parts of the economy."[22]

In this approach, the central government ministries, most notably the Ministry of Economic Affairs and Climate, allocate funds to support innovation pursuant to certain broad parameters, but without specifying exactly how the funds are to be spent. Typically, the funds go through several layers of intermediary organizations comprising business, academic, and public stakeholders, often guided by advisory bodies of experts. "The Netherlands has a rich array of intermediaries that together provide space for a consensus to emerge in a more 'bottom-up' style . . . than is typical in other OECD countries. As such, they moderate 'top-down' steering efforts and provide for 'negotiated changes' in innovation policy and its governance."[23] The intermediary entities pass the government funds through to lower-level actors, commonly adding some of their own funding, with increasing specificity at each level as to how the funds are to be used, a process which typically mobilizes significant private investment.

Thus, for example, in 2020, the central government allocated €11 billion to the newly created National Growth Fund with a broad mandate to promote novel technologies, enable economic growth, and address major societal challenges. The fund made major funding awards to a number of second-tier funding entities directed at narrower, more thematic goals:

- Growth Fund for NXTGEN HIGHTECH (€450 million), committed to developing ultra-precise machines and equipment for applications across a range of high-tech sectors.
- Growth Fund for Quantum Delta (€615 million), with a mission to develop quantum computers, sensors, and communications networks.
- Growth Fund for PhotonDeltaNL (€470 million), dedicated to the development of photonic semiconductor devices.
- Growth Fund for the Einstein Telescope (€42 million, with €870 million in reserve earmarked for future investments), a project undertaken jointly with Belgium and Germany to develop an underground observatory for measuring gravitational waves, which, if successful, will enable scanning of areas of the universe one thousand times more accurately than is now possible.
- Growth Fund for Groenvermogen NL (€338 million), a project to develop green hydrogen as an alternative energy source to fossil fuels.[24]

The second-tier funds in turn make awards that are limited to themes relevant to their respective missions. NXTGEN HIGHTECH, for example, which is committed to developing ultra-precise machinery, has made over 40 awards in six focus areas—laser communications, faster

semiconductors, automated production equipment for lightweight materials and composites, production equipment for chips enabling miniature diagnostics ("Lab-on-a-Chip"), and robotics with agricultural applications.[25] NXTGEN HIGHTECH has 330 project partners, including research universities, regional development authorities, research organizations, and private companies.[26]

Governance at the Regional Level

Regional governments have evolved their own forms of network governance with respect to their role in the innovation ecosystem—specifically, the management of local research facilities, science parks, workforce issues, and infrastructure. Originally, regional collaborations evolved when municipalities responded on an ad hoc basis to address issues of regional concern. In 2015, the Netherlands enacted the Law on Collaborative Arrangements, which enabled the granting of legal mandates and resources to such voluntary collaborations.[27] Regional development agencies now form an important part of the country's innovation ecosystem. Examples include:

THE INNOVATION QUARTER

This organization is the economic development agency for the province of South Holland, which includes the cities of Rotterdam, Delft, the Hague, and Leiden. Its stakeholders include universities, government agencies, major companies, and small- and medium-sized enterprises (SMEs), and it functions as a networking organization linking these entities and conducting outreach to potential international partners. The Innovation Quarter invests in startups with high potential through four funds, each targeting various stages of technology readiness:

- **UNIQ** is a €22 million seed fund with a multi-sector focus that invests up to €300,000 per company, with an emphasis on the proof-of-concept phase.
- **Energiq** is a €35 million fund focusing on energy transition, investing up to €5 million per company for pilot and demonstration, commercialization, production, and internationalization. It funds the commercialization of proven energy innovations that lead to CO2 reduction.
- **IQ/Capital** is an €80 million fund with a multi-sector focus, investing up to €5 million per company for pilot and demonstration, commercialization, production, and internationalization. It funds disruptive startups and scale-ups with high technological risks and the need for patient capital.
- **Energietransitiefonds Rotterdam** is a €100 million fund focusing on energy transition and circularity, investing €1-10 million per company. It finances disruptive companies and sustainable projects that achieve CO2 reduction, improve air quality, and reduce the use of raw materials.[28]

THE BRABANT DEVELOPMENT AGENCY (BOM)

BOM was established in 1983 by the Province of North Brabant and the Ministry of Economic Affairs, both of which remain shareholders.[29] It is a "cluster builder," supporting startups, scale-ups, and established companies to commercialize promising technologies. According to the consultancy Dealroom, BOM is a leading investor with one of the strongest networks in the Netherlands. In

2024, it facilitated 10 foreign companies in establishing or expanding in Brabant.[30] BOM operates a venture capital arm, BOM Brabant Ventures; manages a new €100 million capital fund focusing on defense technologies, SecFund; and has recently launched an AI supercomputing initiative in conjunction with the Province of North Brabant and local universities to make supercomputing resources more democratically accessible.[31]

These programs all have the virtue of focusing on the funding requirements of early-stage firms; yet, as with many funds in Europe, they can lack scale and speed, characteristics often associated with public funding.

Key Institutions and Programs

In the Dutch innovation system, "triple helix" or "golden triangle" arrangements are the norm, featuring collaboration between industry, government, and academia. Importantly, many of the companies and institutions mentioned in this paper are stakeholders in one another, forming an interconnected web that is reinforced by myriad informal interpersonal relationships between and among stakeholders. This dense network enables the rapid exchange of information, the brainstorming of ideas, and the quick formation of ad hoc groupings to address new challenges as they arise. Many of today's stakeholder organizations have their origins in such improvised alliances and are quick to assist new combinations formed to respond to emerging challenges.

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TNO, "the Netherlands' Fraunhofer"

TNO, the Netherlands Organisation for Applied Research, occupies a space in the Dutch innovation system loosely analogous to that of the Fraunhofer Gesellschaft in Germany, performing contract research for companies and government agencies, contributing to workforce development, and fostering spin-offs and startups. Like the German Fraunhofer, TNO operates through a distributed

system of regional branches. Not surprisingly, TNO is collaborating with the Fraunhofer in research into a range of themes of critical interest to both countries, including microelectronics, AI, and intelligent energy networks.[32]

TNO is an independent, not-for-profit public organization created by statute in 1932 to foster applied scientific research in conjunction with companies (including SMEs), government agencies, and EU joint research projects. At present, it is the largest independent research and development (R&D) and consultancy organization in the Netherlands, with a staff of over 3,000. TNO derives its revenues from a mixture of market-based income—primarily contract research for industry and research organizations (€403.3 million in 2024)—and government funding (€361 million in 2024).[33] Government funding is derived from three principal sources:

- The Ministry of Economic Affairs provides funding (€200 million in 2024) "to develop, apply, and disseminate knowledge, and resolve societal issues." These funds support "Early Research Programmes" (basic research) and "Demand Driven Programmes."[34]
- Other Dutch ministries provide earmarked funds to support research directed at specific topics or themes, including statutory, knowledge-intensive, task-related research for the Ministry of Defense and the Geologic Survey of the Netherlands (€161 million in 2024).
- TNO receives funding from public entities participating in collaborative projects and receives funding through competitive grants from public programs such as EU Horizon Europe.[35]

TNO operates its own investment arm, TNO Ventures, to assist spin-offs from TNO as well as startups that have emerged independently, providing IP licensing and counseling, labs, cleanrooms, and technical support services, for which it accepts shares in the ventures in lieu of cash. TNO Ventures is currently supporting startups in integrated photonics, AI, and medical technology. The investment arm also participates in 12 early-stage investment funds, including Photonventures, DeepTechXL, and Innovation Industries.[36]

The Dutch Research Council (NWO)

NWO is an independent administrative body operating under the Ministry of Education, Culture, and Science promoting innovation in science. Its annual budget of roughly €1 billion is directed toward Dutch universities and research organizations.

- NWO operates nine research institutes specializing in themes such as subatomic physics, radio astronomy, nanolithography, and oceanic research.[37]
- One of NWO's research organizations, CWI Amsterdam, specializes in mathematics and theoretical computer sciences. It has developed numerous programming languages, including Python, one of the most popular, with widespread use in machine learning. CWI also operates an incubator that has generated a substantial number of startups.[38]

Technical Universities

The Netherlands has four strong technical universities that engage in both fundamental and applied scientific and engineering research. Together, they form the 4TU Federation, featuring education with an emphasis on innovation.[39] The four universities launch spin-offs to commercialize innovations in fields such as battery technology, data center management, and high-powered microwave communications.[40]

- **The Delft University of Technology (TU Delft)** is the oldest and largest technology university in the Netherlands, with a staff of 5,000 and an enrollment of over 19,000. It conducts scientific research in a broad range of fields with funding from the Ministry of Education, Culture, and Science, as well as contract research for industry.[41]
- **The University of Twente (UT)** in Enschede enrolls over 12,300 undergraduate and graduate students. UT places a heavy emphasis on innovation, and supports initiatives in hydrogen-generated energy, "green steel" (sustainable steelmaking), water and membrane technology, semiconductors, and photonics. Its New Origin Program is establishing a production facility for photonic chips.[42]
- **The Eindhoven University of Technology (TU/e)** enrolls 13,000 students seeking to become "future proof engineers," operating separate institutes for complex molecular systems, AI, renewable energy, and the integration of electronics, photonics, and quantum technologies.
    - At TU/e, the different science and engineering departments work closely with the centers and institutes in these key areas.[43]
    - TU/e offers nano-laboratories, special ICT support, cleanrooms, and expertise to internal and external users.[44]
    - The TU/e Innovation Lab offers support for startups in the form of research, business support, and entrepreneurship counseling.[45] The Innovation Lab also collaborates with SMEs in the area on projects and manages and advises the areas, centers, and institutes of the TU/e and SMEs, working closely with and connecting them with relevant faculty across the university.[46]
- **Wageningen University & Research (WUR)** in Wageningen, enrolling about 12,000 students, focuses on life sciences and natural resources. It supports 10 research institutes in fields such as environmental science, dairy, food safety, plant research, and bioveterinary research.

Three of the 4TU universities–TU/e, TU Delft, and UT–combine to offer joint degree programs in fields such as embedded systems, cybersecurity, systems and control, and sustainable energy. The four universities jointly operate a number of research institutes:

- **The Stan Ackermans Institute** manages two-year postgraduate designer programs in 21 industry-relevant fields, such as industrial engineering, automotive systems design, electrical engineering systems design, robotics, software technology, and civil engineering.[47]

- **The Applied Mathematics Institute (3TU.AMI)** coordinates the activities of the mathematics groups at the three universities, in addition to those of the University of Groningen.[48]
- **The 4TU Centre for Research Data** is a data archive for scientific and engineering data. It currently houses over 10,000 datasets.[49]

Universities of Applied Science

The Netherlands has the advantage of a considerable body of 41 universities of applied science (hogeschool) that focus on training students on practical work in specific professions through internships and fieldwork, rather than scientific research (a gap in the U.S. innovation system that new programs seek to address). These institutions correlate roughly with polytechnics in other countries and community colleges in the United States, although the Dutch schools of applied sciences are accredited to confer bachelor's and master's degrees, unlike the international polytechnics and U.S. community colleges.[50]

The National Growth Fund

In 2020, the Dutch central government launched the National Growth Fund as a vehicle to invest €11 billion in 50 projects that develop novel technologies, enable economic growth, and create solutions for global societal challenges. The fund is managed jointly by the Ministry of Economic Affairs and Climate and the Ministry of Finance, and makes grants to companies, educational institutions, public entities, civil society organizations, and other organizations.[51] A committee of independent external advisers makes recommendations with respect to funding decisions that the government can accept or reject. This committee draws on a wide range of knowledge institutions as well as the Netherlands Bureau for Economic Planning Analysis in formulating its recommendations.[52] As noted above, the National Growth Fund invests in numerous thematic, mission-specific growth funds that are created by industry, government, and academic consortia.

In March 2024, following a parliamentary vote, the Ministry of Economic Affairs and Climate cancelled the next round of grant proposals, effectively suspending future outlays by the National Growth Fund. Some of the parties in the governing coalition did not support a new round of grants. "Although this doesn't necessarily mean they want to dismantle [the Fund], its fate now seems to hang in the balance," as Paul van Gerven, a Dutch technology expert, noted.[53] Various public, private, and academic stakeholders are calling on the government to continue public funding of private research and development. Given the dramatic increase in international competition in high-tech industries, reducing investment in these areas appears problematic. Substantial support, sustained over time, and sufficient flexibility to address new opportunities in emerging technologies are crucial aspects of a competitive innovation ecosystem in today's global high-tech competition.

Programs Supporting Startups

The Netherlands hosts a constellation of high-tech incubators and accelerators to foster startups and scale-ups, several of which are profiled in this paper. According to Startup Genome's 2022 Global Startup Ecosystem Report, the Netherlands is Europe's fourth-best country for startups.[54] The country features a number of support measures that directly target startups or that benefit them along with established companies.

- **Seed angel investment.** The government offers loans to investors who want to make angel investments to startups.
- **Innovation tax credit.** Companies developing new products, processes, services, or drugs can qualify for the generous Dutch innovation credit.
- **Loan guarantees.** The government offers a number of programs that guarantee bank loans to SMEs.
- **Seed Capital Program.** This program, developed by the Ministry of Economic Affairs and Climate, provides capital support to investment funds that commit risk capital to innovative initiatives in the technology and creative sectors.
- **30 percent ruling.** This tax incentive benefits companies that employ highly skilled migrants in the Netherlands, offering that the migrants will only be taxed on 70 percent of their income, enabling the payment of higher salaries to migrant employees.

While these programs, and a number of those described below, show considerable promise, a key challenge for the Netherlands' innovation system remains its ability to scale promising firms in a timely manner.

Growing the Brainport Eindhoven Cluster

The epicenter of innovation in the Netherlands is "Brainport Eindhoven," a designation and branding term comprising the city of Eindhoven and 20 other municipalities around the city, all in the province of North Brabant ("Brabant"). This area hosts over 5,000 high-tech/IT firms and 73,000 knowledge workers. Two percent of all patents worldwide originate in Brainport Eindhoven, and the area is frequently cited as one of the most successful technology clusters in the world.[55] ASML originated in what is now Brainport, and the regional ecosystem played a decisive role in the company's eventual success. If the Dutch succeed in creating new ASMLs, it is likely to happen here.

Eindhoven emerged as a technology-intensive area largely because of the longstanding presence of Philips, a major electronics firm. Established in Eindhoven in 1891 as a manufacturer of light bulbs, Philips grew into one of the largest producers of electronics products in the world. By the mid-1970s, Philips had over 2,000 employees engaged in R&D in its Dutch research center, the Philips Physics Laboratory (NatLab). The company introduced watershed innovations such as the compact cassette audio tape format (1963), the first boombox (1966), and the first commercial VCR (1972).

Philips provided a wide range of local community services, including housing, education, healthcare, and sports and recreation. The company founded the renowned soccer club PSV Eindhoven. As a local business development manager stated, "There were Philips doctors, a Philips medical centre, and even in hard times of economic crises, there were even Philips soup kitchens, where people could get their food."[56] Largely thanks to Philips, Eindhoven developed a robust innovation infrastructure, a well-educated population, and an appealing urban character.

The Philips family promoted social networks and strong links between local communities—all of which would stand the region in good stead during the successive economic crises that buffeted the region in and after 1990. As Hans de Jong, president of Philips Netherlands, later recalled, "During good times you have to build relationships based on common interests, so that help is 'a phone call away' during a crisis."[57]

BRAINPORT—FORGED IN CRISIS

Philips ran into financial difficulties in the 1990s and undertook a radical restructuring of its operations, shutting down or relocating a number of its manufacturing sites.[58] Some of its businesses were spun off, including what would become ASML and NXP Semiconductor. The Eindhoven area lost 35,000 jobs and was staring at the prospect of precipitous economic decline.

In response, the mayor of Eindhoven, Rein Welschen, the chancellor of TU/e, Henk de Wilt, and the chairman of the Association of Industrial Companies, Theo Hurks, convened to brainstorm solutions to the area's crisis. They organized a roundtable conference, drawing in all of the stakeholders in the region to formulate a joint action plan.[59] This convention is now recognized as the beginning of triple helix collaboration in the region, drawing in 21 municipalities, including Eindhoven itself.

- Welschen and de Wilt formed the Commission for Regional Opportunities, which launched a program dubbed Horizon. The program leaders convened about 40 meetings with local entrepreneurs, who until then had not collaborated significantly, and persuaded them to participate in a succession of innovation-based development projects pursuant to the triple helix principal, featuring cooperation between industry, local universities, and government agencies.
- At the urging of Mayor Welschen, the 32 local councils in the region donated about €5 per capita from their districts, creating a fund for financing projects.[60]
- The leaders of Horizon succeeded in securing 67 million European currency units from the European Union.
- The coalition achieved additional success when, in 1997, Philips moved its headquarters to Amsterdam but was persuaded by local leaders to allow the use of old Philips patents by small businesses in the area and to strengthen its R&D activities in Eindhoven. This resulted in the creation of the "Philips High Tech Campus" (see below).[61]

THE DOT.COM BUBBLE

After the collapse of the dot.com bubble in 2000, a second crisis developed in the form of a local recession and the curtailment of operations by local manufacturers, including ASML. A collective effort was launched by industry, academic, and government leaders to address the region's challenges that was dubbed "Brainport," a designation that was subsequently formalized under the rubric "Brainport Eindhoven."

- The Brainport Foundation was established in 2005 as a convening point where CEOs, mayors, and chancellors of local universities could address regional development. The foundation comprises 15 members, 5 each from government, industry, and academia. As one scholar has described it, the foundation "drafts the strategic agenda for the economic development of the Brainport region."[62]
- Brainport Development was created as an operational entity to coordinate and implement the development strategy formulated by the Brainport Foundation. Directed by the foundation, the organization must enact new programs and projects and engage in lobbying with the regional partners to meet strategic goals.[63]
- The Brainport effort was intended to offer a straightforward method by working with CEOs and those with managerial power who were in tune with market dynamics."[64]

THE 2008 FINANCIAL CRISIS

Another crisis occurred in 2008, in the wake of the global financial collapse, which adversely affected Dutch financial institutions.

- Regional leaders feared that an exodus of unemployed knowledge workers would permanently cripple the local innovation economy.
- In response, Brainport Eindhoven CEOs and government officials negotiated a deal with the central government pursuant to which knowledge workers were allowed to work part-time without a reduction in income, with the difference made up by subsidies from the government.

THE COVID-19 PANDEMIC

The pandemic, which began in 2020, brought another economic shock to the region, with lockdowns curtailing research and manufacturing operations.

- Brainport Eindhoven leaders provided funding for "healthy" startups to enable them to survive the crisis, with support from ASML, NXP, Philips, Brainport Development, TU/e, the municipality of Eindhoven, the province of Brabant, and others.
- With support from Brainport Development and the central government, local enterprises were able to convert their production operations to supply medical equipment needed to combat the pandemic, including ventilators.[65]

The series of economic crises that buffeted Eindhoven in and after 1990 led to the creation of institutions and collaborative networks between stakeholders that have demonstrated remarkable adaptability and resilience. Today these arrangements–improvised in response to severe challenges

and now formalized—are enabling the region to flourish. Robert Elbrink, head of the Strategic Department for the Municipality of Eindhoven, reflected that "Crisis forced the authorities, educational institutions and the business community within the Eindhoven region to cooperate, these were the 'defining moments' of the network."[66]

One retrospective assessment of the emergence of Brainport Eindhoven credits the "culture of entrepreneurship" in southeast Brabant, "which has always been necessary on this poor sandy soil[,] has also contributed to a resilient basis for development. These poor soils enhanced a 'DNA of cooperation and urge to survive.' So cultural 'soft' factors, such as the tradition of cooperation and taking initiatives in Brabant, the hands-on mentality, and the eagerness 'to put Eindhoven on the map' were important in this process."[67]

ASML's Regional Role

ASML is located in Veldhoven, one of the 21 municipalities that compose Brainport Eindhoven. It is the fastest-growing firm, the largest employer, and the largest investor in R&D in the region.[68] It employs over 42,000 people from 143 nationalities and has a network of nearly 5,000 first-tier suppliers.[69] According to former NatLab employee Maarten Buijis, "The pinnacle of economic prowess, [ASML has] turned the Brainport region into one of the most influential spots on earth."[70] It grew out of, and continues to draw support from, a local innovation ecosystem that is now a model for Dutch policymakers. The emergence of ASML was a decades-long evolutionary process in which technological infrastructure played a particularly important role.

BUILDING ON THE PHILLIPS NETWORK

Philips spun off ASML in 1984 as a 50/50 joint venture of Philips and ASM International. Philips continued to provide essential support as the new company struggled to improve its lithography equipment, then inferior to that available from firms like Nikon and Canon. Philips "kept its litho subsidiary going until about 1992. It saved ASML from collapse," as Dutch industry expert René Raaijmakers notes.[71] Additionally, according to Marc Hijink, a Dutch financial journalist, ASML enjoyed access to "Philips' crown jewels . . . including the NatLab, which rivaled large research labs such as those of IBM and AT&T. From 1985 onward, the Philips Center for Manufacturing Technology (CFT) also came to play an important role . . . The significance of these Philips sources can hardly be overestimated."[72]

Eindhoven already hosted numerous Philips supply chain vendors and, as the company retrenched after 1990, former Philips employees set up new specialist companies, which became part of ASML's local supply chain. As Hijink puts it: "And so a network of manufacturers took root in the region that knew each other intimately and spoke the same technical language . . . quite literally. Every component for ASML has a 12-digit code, based on the 12nc system that Philips used for decades in its own factories. Forty years after its founding, the code of all ASML components still starts with '4022.' . . . [This coding system] is the key to a system that holds together a complex global chain of production, a code that unmistakably bears the DNA of Philips."[73] The complex system developed as:

- ASML deliberately sought suppliers of its most critical components from the Rhenish countries (Netherlands, Germany, Switzerland, France) because there, according to Hijink, "solidarity and craftsmanship are traditionally deemed far more important than a polished set of quarterly figures."[74]
- The ASML supply network grew in size to hundreds and then thousands of companies, initially mostly based in Brabant or immediately adjacent regions.[75] As of 2017, 70 percent of ASML's first-tier suppliers were located within 20 kilometers of Eindhoven.[76]
- Most significantly, ASML developed a crucial supply relationship with Carl Zeiss, a maker of precision optical lenses based in the German state of Baden-Württemberg, which is perhaps the company's most critically important vendor. Zeiss produces the lithography optics that make EUV lithography possible. In 2017, ASML acquired a 24.9 percent minority interest in Carl Zeiss SMT GmbH, the semiconductor manufacturing subsidiary of Carl Zeiss AG.[77]

Philips began to wind down its support for ASML after 2000, and thereafter ASML pursued research support from other actors in the region; as Raaijmakers observes, particularly "from TNO, suppliers, and university research centers. As a result, an extraordinarily powerful R&D organization arose, embedded in a world-class technological ecosystem. This epicenter of physics doesn't just develop the most complex machines but all the relevant technology to enable chip factories to shrink the details on chips."[78]

SUPPORT FROM TNO

TNO began providing support to ASML in the 1990s and made important contributions to the company's successful development of extreme ultraviolet (EUV) semiconductor technology. TNO believed in the potential of EUV lithography and favored a multidisciplinary approach to its development, making it a "perfect partner to accompany ASML."[79] Working with ASML, TNO built the first EUV lithography prototypes and worked on various critical aspects of the hardware needed to enable EUV machines to function.

- TNO worked with ASML to create a reticle handler capable of meeting EUV's extreme accuracy and cleanliness specifications. TNO also developed a method for positioning the reticle using a pre-alignment sensor from the space industry, utilizing algorithms for positioning satellites based on the position of stars, and thus ensuring extraordinarily accurate alignment with the EUV scanner.
- TNO used its contamination and cleaning expertise, acquired in the space and high-tech industries, to develop a vacuumized storage box housing the reticle, built in compliance with the extremely strict requirements for particles and reticle cleanliness.
- To enable the vacuum environment required by EUV, TNO combined with Philips and Berliner Gas (now ASML Germany) to design an electrostatic clamp that holds either reticles or wafers in position with extraordinary precision inside a vacuum environment.
- TNO and ASML jointly developed the level sensor, a device used for fast, accurate mapping of the wafer topography.

- ASML has adopted a novel mirror control that TNO developed for laser satellite communications.[80]
- In 2025, TNO continues to provide support to ASML in areas such as optics and contamination control. The company operates advanced facilities like EUV Beam Line 2 (EBL-2), where ASML and its customers can measure, inspect, and analyze contamination and cleaning equipment.[81]

R&D SUPPORT FROM IMEC

ASML received critical research and development support from imec, Europe's foremost microelectronics R&D center, located in Leuven, in the Belgian region of Flanders, about 50 miles from Eindhoven. Imec CEO Luc Van den hove summarized the consortium's relationship with ASML in March 2024: "We have a very close partnership with ASML. In fact, imec was started in the same year as ASML, in 1984. . . . And we built up a very strategic partnership with them. And we installed first of a kind [sic] tool for every generation, and imec developed the process. So ASML focuses on the machine. We develop the process. We develop the ecosystem around the machine."[82]

- Before the first EUV-based lithography tool was available, imec conducted tests using EUV radiation generated by a synchrotron at Switzerland's Paul Scherrer Institute.
- Imec developed the first EUV light source, which underpins EUV lithography.
- Imec created the first EUV optics, which focus ultraviolet light onto a semiconductor wafer.
- Imec collaborated with ASML to develop the software that controls EUV lithography machines.
- Imec collaborated with six makers of photoresists to develop EUV photoresists.
- In 2006, ASML made the first full-field EUV lithography tool, the Alpha Demo Tool, which was provided to imec and New York's College of Nanoscale Science and Engineering (CNSE) to assess its commercial viability and to identify operational challenges on pilot lines in a real factory environment. Imec has worked with ASML to prove and test subsequent generations of ASML EUV tools.[83]
- In June 2023, imec signed a memorandum of understanding with ASML to install and service ASML high NA-EUV lithography and metrology equipment for a sub-1 nm pilot line at imec's Leuven facility.[84] High NA ("numerical aperture") lithography machines enable much faster wafer throughput than the previous generation NXE systems (introduced in 2010) and can be used to produce 2 nm and below semiconductors.[85] Imec has secured commitments of €750 million each from the EU and the Flanders government to support this project.[86]

Brainport Today—A World-Class Innovation Ecosystem

Dealroom, a consultancy specializing in technology ecosystems, ranks Brainport Eindhoven seventh out of the 201 best tech ecosystems in the world, citing its leading position in deep-tech, university talent, and patents.[87] In 2025, within Brainport, there are five major location-specific "hotspots" for innovation and entrepreneurialism that are co-located with R&D centers to

facilitate industry-academic collaboration and the transfer of tacit knowledge (know-how)—High Tech Campus Eindhoven (HTCE), Brainport Industries Campus (BIC), the Technical University of Eindhoven (TU/e), Strijp-S (on the site of the original Philips industrial park), and the Automotive Campus, dedicated to autonomous and smart vehicles and green automotive technologies.[88]

HIGH TECH CAMPUS EINDHOVEN (HTCE)

During the crisis years, Philips—although downsizing substantially—continued to provide significant support to the local innovation infrastructure, most notably the contribution of a site for high-tech innovation. In 1998, Philips concentrated all of its international R&D activities at a single location in Eindhoven, the Philips High Tech Campus. It opened the campus to other companies in 2003, renaming it High Tech Campus Eindhoven. In 2012, Philips sold the campus to private investors, continuing to operate at the site as a tenant.

In 2025, HTCE, with a size of one square kilometer, is recognized as one of the best sites in the world to foster entrepreneurialism and startups. As of 2024, it hosted 12,500 knowledge workers and major companies such as Intel, Accenture, IBM, NXP, Texas Instruments, and Analog Devices. In addition, a number of publicly funded research organizations are located on the campus, including:

- **The Holst Centre.** Located at HTCE, the Holst Centre is an industry-government research center jointly established in 2005 by TNO and imec.
  - The Holst Centre specializes in R&D in flexible electronics and wireless sensor technology.
  - It employs over 180 specialists from 28 countries and is equipped with state-of-the-art facilities for hybrid printed electronics and development of thin film transistors and specialized materials.[89]
  - Holst is particularly valued for its ability to develop demonstrators and prototypes.[90]
  - Most of Holst's funding is derived from its research partners, who pay fees and sometimes provide research resources in return for intellectual property developed at the Holst site.[91] In addition, Holst is supported by funding from national, regional, and local government organizations.[92]
- **TNO-ESI.** A collaboration between TNO and the Embedded Systems Institute (ESI) at the TU/e, TNO-ESI aims to foster high-tech embedded systems design and systems engineering.[93] Among other initiatives, TNO-ESI has driven the Mastering Complexity Program (MASCOT), which enables the fast development of high-quality future industrial systems at low cost by training students to manage the increasing complexity of high-tech systems. The explicit goal is to create a "continuous, seamless pipeline" from academic research to industrial application.[94]
- **Soliance.** Located in HTCE, Soliance is a joint venture between TNO and imec to develop next-generation, thin-film solar cells.[95] It consolidates and coordinates the activities of 250 researchers from industry, universities, and research institutes.[96]

- **Pixeurope pilot line.** TNO is spearheading an initiative to establish a 6-inch-wafer pilot line for indium phosphide photonic chips in HTCE. The pilot line, part of the EU Pixeurope Initiative, is being jointly funded by TNO, the EU Chips Act, the Dutch Ministry of Economic Affairs and Climate, Photondelta (a Dutch nonprofit supported by the National Growth Fund), and the Dutch Ministry of Defense. Ton van Mol, managing director of TNO, claims that "this pilot line is a game-changer for Dutch companies and the future earning power and prosperity of the Netherlands. It's a critical part of a powerful ecosystem in photonic chips with which the Netherlands can distinguish itself worldwide."[97]
- **High Tech XL.** Also located in HTCE, High Tech XL is a so-called deep tech venture builder, or an entity that supports new ventures to commercialize discoveries made in Dutch and EU research organizations that have transformational potential but require sustained investments over the longer term to succeed. High Tech XL is rated as one of the top five startup builders in the world.[98]
    - High Tech XL is the creation of Guus Frericks, an industrial engineer with experience at Philips and NXP Semiconductor, who observed the emerging deep-tech cluster in Eindhoven and believed it could be systematically mobilized to launch deep-tech startups. He noted that ASML survived initially, then succeeded in dramatic fashion, because it was "enabled by an elaborate ecosystem." He asked, "What if we could replicate the story of ASML, by mobilizing the power and unique strength of the local ecosystem? What if we could create the next BSML, CSML, DSML, and so forth?"[99]
    - High Tech XL created the Eindhoven Startup Alliance, comprising the major players in the regional ecosystem, ASML, Philips, TNO, HTCE, BOM, Brainport Development, TU/e, the Municipality of Eindhoven, and other stakeholders. According to Georges Romme of the Eindhoven University of Technology, "This alliance operates as a platform providing support in all stages of the [deep-tech venture] journey," with the members providing ventures with expertise, access to lab facilities, and connections with leading research institutes.[100] High Tech XL provides its ventures with training, workshops, capital, and access to its network.[101]
    - Hi Tech XL operates a rigorous multi-phase process to identify promising technologies and then select and support startups to develop and move those technologies through the "Valley of Death" to weed out failures and bring the best startups to commercialization. The most promising technologies originating in Dutch and EU research organizations are identified through a "Fas Trackathon," in which the technologies and their potential applications are discussed by engineers, physicists, experienced entrepreneurs, financial experts, and business developers. The technologies are primarily drawn from TNO, CERN (European Organization for Nuclear Research), the European Space Agency (ESA), Philips, and confidential stakeholders.
    - High Tech XL builds venture teams to take the most promising technologies to market, adding individuals with the perceived needed skillsets. These teams enter into High Tech

XL's nine-month venture-building program and are incorporated as legal entities. High Tech XL and the venture's CEO and chief technology officer (CTO) hold the initial equity.

- High Tech XL monitors the developmental progress of ventures through nine "maturity levels" distributed across three broad phases roughly corresponding to the technology readiness level (TRL) scheme. The phases act as a funnel, with only those ventures that deliver the required results moving to the next phase.
- Winning teams enjoy mentoring, weekly workshops, pitch training, video production support, and access to a network of experts, potential customers, suppliers, IP lawyers, and financial experts.[102]

BRAINPORT INDUSTRIES CAMPUS (BIC)

The Brainport Industries Campus is a 105,000-square-meter innovation center in Eindhoven supporting innovation in manufacturing. BIC was created because of the need for "an actual manufacturing campus … a place where the entire manufacturing chain is located."[103] It convenes original equipment manufacturers (OEMs), supply chain companies, research organizations, and universities to work together on high-tech manufacturing challenges. BIC features clean rooms, flexible manufacturing facilities, research and prototyping infrastructure, warehouses, and an automated logistics system to support manufacturing.

- BIC houses over 50 companies and 3 educational institutions and enjoys a "vibrant student community" where students can complete internships and graduation projects and refine their practical skills. One company present at the site said that the proximity of students "facilitates our talent acquisition."[104]
- BIC is owned by the Municipality of Eindhoven, which acquired it in March 2025 from Capreon, a private equity firm that will remain on site as an asset manager to ensure a smooth transition.
- BIC-1, the current facility, will be augmented by BIC-2, a new facility roughly twice the size of BIC-1, with construction scheduled to begin in 2026 and operations in 2027.[105]
- BIC-2 is of critical importance to ASML, which will use the site for its planned expansion involving 20,000 new jobs.[106]

OPERATION BEETHOVEN

The central government's caretaker administration of Mark Rutte unveiled Operation Beethoven in the spring of 2024. Operation Beethoven is a €2.51 billion plan to be funded by the central and regional governments to support the semiconductor industry, with the objective of forestalling a move by ASML to partially or wholly relocate outside of the Netherlands.

- The central government pledged to provide €1.73 billion (€1.28 billion drawn from the National Growth Fund and €0.45 billion from the Mobility Fund, a government fund supporting transportation infrastructure), with the remainder provided by regional authorities.[107]

- The funding is being allocated to workforce and housing initiatives to enable ASML to expand in the planned BIC-2 facility and add 20,000 new jobs by 2030.[108] In April 2024, ASML signed a letter of intent to undertake the proposed expansion at the BIC-2 site.[109]
- Operation Beethoven funding is also being allocated to the Technical University of Eindhoven to finance a €200 million expansion program that would enable it to train an additional 2,000 master's degree students in programs relevant to the semiconductor industry. ASML is committing €80 million to this effort, which would involve construction of new cleanroom to be operational in 2027.[110]

However, numerous hurdles to the successful implementation of Beethoven have emerged.

- **Electricity.** The principal obstacle to ASML's expansion is the inadequacy of the local electricity grid to support operations at BIC-2. Beethoven calls for the construction of 116 new medium-voltage substations and upgrading a significant number of transformers while minimizing disruption to local communities.[111] To facilitate ASML's expansion by increasing grid capacity, grid operator Enexis, as well as local municipalities, are facing growing pressure to find solutions.[112]
- **Housing.** Beethoven envisions construction of 60,000 new homes by 2030 to accommodate the expansion of ASML's work force, and the company is contributing to the Beethoven Housing Fund. However, the municipalities where the construction will take place confront rising construction costs, shortages of skilled labor, and delayed permit approvals, all made worse by the "nitrogen crisis."
- **Nitrogen.** The Netherlands has the highest nitrogen emissions concentration per hectare in Europe, primarily a result of livestock farming.[113] As a result of a 2025 domestic court ruling, as well as demands from the European Union, the country is under pressure to halve its nitrogen emissions, pressure which, if successful, threatens to stall approvals for new housing projects, including those envisioned for Brabant pursuant to the Beethoven plan.[114]
- **Talent.** To ensure sufficient numbers of skilled workers to sustain ASML's expansion, Beethoven envisions the expansion of relevant educational programs in the region. For example, the Eindhoven University of Technology foresees doubling its semiconductor student body by 2030. But policy changes—specifically, the coalition government's efforts to curb immigration—are putting the arrival of international students at risk.[115] ASML has warned that it will undertake its planned expansion outside of the Netherlands if excessive restrictions are imposed on the entry of foreign professionals and international students.[116]
- **Regulatory hurdles.** In April 2025, the mayor of Eindhoven, Jeroen Dijsselbloem, urged the central government to introduce a new law that, if enacted, would remove planning and procedural obstacles to the implementation of Beethoven, including the electric power and nitrogen issues. Such a measure would be justified provided that it is directed toward companies and sectors "that are crucial to the national and economic security of the Netherlands. Companies don't have two years to wait for a power cable to their factory," the mayor stated.[117]

The Potential for U.S.-Netherlands Innovation Collaboration

The Netherlands has a centuries-old tradition of international commercial and economic linkages as well as a "highly internationalized science system." The country has been engaged for decades in innovation-oriented collaborations with international partners.

- A 2025 study of Netherlands-Japan collaboration noted that at the forefront were joint efforts in quantum technology and photonics, which both countries regard as crucial to their future development. The study found that joint activity was more than twice the world average for quantum technology and nearly four times the world average for photonics.[118]
- The Netherlands' Philips enabled the success of Taiwan's TSMC, currently the world's most advanced manufacturer of semiconductors. At a time when most observers thought that TSMC's foundry model would never work, Philips took an initial 27.5 percent stake in the company when it was launched, provided technology and intellectual property, and was a major early customer. Philips' spin-off ASML continues to work closely with TSMC on the applications of its EUV lithography machines in TSMC's facilities.[119]
- The Netherlands plays an important role within the European Union, participating in EU-sponsored R&D programs and offering comprehensive advice with respect to the future direction of EU innovation policy.[120]

This international approach, along with a focus on mutually advantageous cooperation, may bode well for greater participation by Dutch actors in the U.S. innovation ecosystem, particularly in sectors regarded as strategic by U.S. policymakers, such as semiconductors, quantum technology, artificial intelligence, cybersecurity, and drones.

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One major advantage is the current Dutch strategy of developing world-beating technologies to enable participation in international value chains on a cooperative basis with significant assets and capabilities. This approach arguably meshes with U.S. policymakers' efforts—both at the national and state levels—to establish secure R&D and manufacturing capabilities in the United States. Given Dutch capabilities and focus, the Netherlands could well support efforts to address blank spaces in industry roadmaps. In contrast to some countries that have leveraged U.S. collaborations primarily to extract technology, the Dutch approach is to bring its own capabilities in essential technologies to the table to gain a seat.

Bilateral economic relations are already positive. The United States had its largest bilateral trade surplus with the Netherlands in 2024. U.S. exports of goods and services to that country were $123.9 billion and imports from the Netherlands were $50.9 billion, producing a $70 billion U.S. surplus.[121] The longstanding cooperative relationship between the two countries accounts for over 1 million U.S. jobs, reflecting both Americans working for Dutch companies in the United States and jobs derived from U.S. exports to the Netherlands.[122] While both countries have experienced periods of political uncertainty, bedrock values align. The Netherlands is a staunch, longstanding U.S. ally and a "like-minded" democracy able and willing to cooperate with the United States.

Some U.S.-Netherlands collaboration in the innovation space is already under way. Significantly, this activity is characterized by Dutch engagement with U.S. states and specialized state and specific federal agencies rather than the federal U.S. government as a whole. This concrete pragmatic approach to cooperation has proven attractive, enabling collaborations that address particular issues of concern to both parties.

- In 2012, the Netherlands Forensic Institute, an arm of the Ministry of Justice, entered into a memorandum of understanding (MoU) with the U.S. National Institute of Standards and Technology (NIST) providing for collaboration in R&D, forensic standards and governance, and education and training.[123] In 2022, NIST chose the first four cryptographic algorithms designed to withstand the assault of a future quantum computer. Researchers from the Netherlands and Belgium were involved in three of them:
  - Researchers from CWI Amsterdam, Leiden University, and Radboud University in Nijmegen created both a public, key-encryption scheme, Crystals-Kyber, and a digital signature, Crystals-Dilithium.
  - The digital signature Sphincs+ was jointly developed by researchers from Radboud University, TU/e, the U.S. firm Cloudfare, and the Catholic University of Leuven (Belgium).[124]

- In 2016, the province of South Holland entered into an MoU with the State of Maryland. What began as a pilot project between two regions became a catalyst for Maryland's soft-landing program, which provides international companies an opportunity to test the U.S. market at an affordable cost. In 2023, the MoU was renewed and updated to focus on cybersecurity, quantum computing, and life sciences.[125]
- In 2018, the Netherlands entered into an MoU with the State of Michigan to assess the strengths and assets of their respective automotive sectors and to promote innovation and sustainable growth.[126]
- In 2021, TNO entered into an MoU with the Johns Hopkins Applied Physics Laboratory (APL) to collaborate in space-related fields such as heliophysics, satellite communications, and exoplanet research, as well as other fields such as additive manufacturing, AI, precision medicine, human-machine interfacing, and chemical detection.[127]
- In 2022, the Netherlands entered into an MoU with the State of California to collaborate on a number of climate-related issues, including the goal of zero-emission vehicles, reduced greenhouse gas emissions, and transitioning to a circular economy.[128]
- In 2024, the Netherlands entered into an MoU with the State of New York to collaborate in semiconductor manufacturing. As part of the partnership, Governor Kathy Hochul announced a program to sponsor up to five SUNY students to attend the Eindhoven Semiconductor Summer School program in the Netherlands.[129]
- In early 2025, the Netherlands entered into an MoU with the State of Arizona to collaborate around economic development and workforce for the semiconductor industry. The announcement was made in January 2025 by Arizona Governor Katie Hobbs, together with Netherlands Minister of Economic Affairs Dirk Beljaarts. This also marked the opening of the Netherlands Business Support Office in Phoenix, expanding the collaboration around joint investments and trade initiatives.[130]

Further opportunities exist and could well be facilitated by greater support for exchanges at the working level within the regional clusters and their universities.

Importantly, these cooperative efforts are characterized by their specificity, cooperation between institutions with unique capabilities, and broader projects that draw in intellectual capital from both sides of the Atlantic. These efforts are not characterized by broad agreements, or even general declarations of intent, but rather focused efforts. In strategic areas such as semiconductors, the role of ASML's technology remains paramount, with the newest machines already installed in the New York Creates research center and active participation of the ASML Connecticut facility. Newer areas of cooperation are emerging such as photonics and quantum computing, and there are opportunities for cooperation across the emerging clusters at the regional or state level in both countries. Indeed, these cooperative efforts may well prove essential for mutual success in light of Chinese investments and progress in these new technologies.

In sum, while the Netherland's innovation system is outstanding, the competitive challenge and the complexity of new technologies require renewed focus. Indeed, a key consideration for

Dutch policymakers would be to maintain or expand investments in advanced technologies while expeditiously addressing regulatory obstacles and infrastructure shortages. Given the intense competition in these advanced technologies, it is clearly in the Dutch national interest to continue to invest in research and development, support successful innovation programs—particularly those that address the need for early-stage capital—and support collaborative relationships with American centers of excellence with the goal of initiating and growing pragmatic, mutually beneficial cooperative programs. There are opportunities for cooperation across the emerging clusters at the regional and state levels in both countries. Indeed, in light of Chinese investments and progress in these new technologies, Dutch and American cooperative efforts may well prove essential for mutual success.

About the Authors

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Thomas Howell is an international trade attorney (currently in solo practice) serving as a consultant to CSIS Renewing American Innovation. During the course of his 40-plus-year legal career, he has represented U.S.-based semiconductor companies and organizations in matters such as the U.S.-Japan trade disputes and litigation of the 1980s, the formation of Sematech in 1986–1987, trade disputes with China (including the first WTO dispute settlement challenge to that country in 2003), and numerous other public policy initiatives. He served as a member of the Defense Science Board on Secure Microchip Supply in 2004. He has also represented U.S.-based industries in trade disputes and litigation in telecommunications equipment, soda ash, photographic film and paper, flat-rolled steel, and renewable energy equipment. In conjunction with his legal work, he developed a specialization in field research in Asia and Europe to produce analytic studies for clients. His subjects include industrial, research, and science and innovation policies outside the United States and foreign market barriers to U.S. exports and investment. The National Academy of Sciences has commissioned and published many of his works, and he has contributed to the academy as a contract writer/researcher producing numerous peer-reviewed chapters and book-length studies. He has published numerous articles and books, the most recent of which was co-authored with Charles Wessner, *Regional Renaissance: How New York's Capital Region Became a Nanotechnology Powerhouse* (Springer Nature, 2020). He is a graduate of Harvard College (1971) and the Boston University School of Law (1977).

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