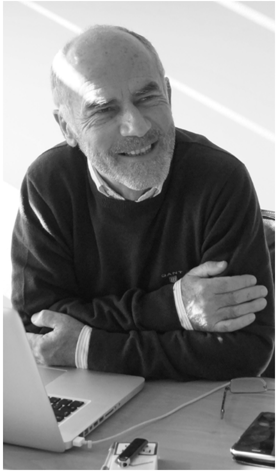
Semiconductors in Portugal

Learning from Cycles,
Building the Future

João Goes
José Epifânio da Franca

NOVA FACULDADE DE CIÊNCIAS E TECNOLOGIA
TÉCNICO UNIVERSIDADE DE LISBOA



José Franca is Professor at Instituto Superior Técnico (IST). In 1997 José Franca co-founded and became CEO and Chairman of Chipidea Microelectronics SA which pioneered and became a worldwide leader in the Semiconductor Analog Mixed-Signal IP industry. Currently with over 900 engineers in Portugal. In 2012 José Franca was appointed by the Government of Portugal Chairman of the Board and CEO of Portugal Ventures, which he served until 2015 with the mandate to establish a modern, internationally recognized technology-based entrepreneurial ecosystem in Portugal laying out solid foundations for the attraction of international venture capital and steady worldwide inflows of talent and experience. In 1986 he founded the Integrated Circuits and Systems Group (GCSI) at IST leading several International and European projects in science, technology, and training.

João Goes has been with the Department of Electrical and Computer Engineering (DEEC), School of Sciences and Technology (NOVA FCT), at NOVA University of Lisbon since 1998, where he is a Full Professor. In 2003, he co-founded and served as the CTO of ACACIA Semiconductor SA, a Portuguese engineering company specializing in high-performance analog frontend products (now RENESAS). From 1997 until 1998 João was Project Manager at CHIPIDEA SA (now SYNOPSYS). He was the first Engineer hired. From 1993 to 1997 he worked as a Researcher at Integrated Circuits and Systems Group (GCSI) at Instituto Superior Técnico (IST) doing research on data converters and filters. Since 1992 he has participated and led several National and European projects in science, technology, and training.

Portugal Ought to Do Better!

May 2026

Contents

Why This Document, Why Now

Portugal's most credible path forward lies in defining a clear role within the European semiconductor system.

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The document treats history as a source of structured insight.

A Strategic Industry at an Inflection Point

Semiconductors have moved from being a specialised industrial domain to becoming a **central pillar of the global economy and geopolitical landscape**. They underpin:

- digital infrastructure
- artificial intelligence
- mobility systems
- energy networks
- defense capabilities
- among many other domains

Their importance is not only technological ⟶ it is **systemic**.

Recent disruptions in global supply chains, combined with accelerating technological competition, have exposed a fundamental reality: control over semiconductor capabilities is increasingly synonymous with economic resilience and strategic autonomy.

This recognition has triggered a global wave of industrial policy initiatives. In Europe, this is embodied in the European Chips Act, which aims to reposition the continent within the global semiconductor landscape.

Portugal: A History of Participation Without Positioning

Within this broader context, Portugal is experiencing renewed interest in semiconductors. This interest is not without foundation.

Over the past four decades, Portugal has:

- hosted multinational semiconductor operations
- developed industrial capabilities in selected segments
- built a strong academic base in microelectronics-related fields
- produced a globally recognised success case in design and IP

Why This Document, Why Now

Yet, despite these elements, Portugal has not established a **stable, clearly defined position** within the semiconductor value chain. Its trajectory has been characterised by:

- discontinuity
- fragmentation
- limited long-term anchoring

This raises a central question: Why has sustained positioning remained elusive, despite repeated participation?

Learning from History

This document is built on the simple premise that effective strategy requires explicit learning from past experience. Rather than treating history as a sequence of events, the document treats it as a **source of structured insight**, and seeks to answer three questions:

What has been done?	→	A reconstruction of Portugal's semiconductor trajectory across multiple phases
What worked and what did not?	→	Identification of recurring patterns and structural gaps
What should be done now?	→	Definition of a realistic and actionable strategic model

From National Narrative to Systemic Analysis

The objective of this work is not to produce a descriptive history, nor a technical treatise. It is to provide a strategic analysis of how a country engages with a complex, global, technology-driven industry where the focus, therefore, is on:

- mechanisms, not anecdotes
- structures, not isolated events
- lessons, not retrospection

A European Context

Portugal's future in semiconductors cannot be understood in isolation. The European Union is now:

- investing heavily in semiconductor capabilities
- seeking to reduce external dependencies
- facing a structural shortage of specialised talent

This creates both:

- **constraints** (scale, competition, coordination)
- **opportunities** (funding, integration, positioning)

A key argument of this document is, therefore, that:

Portugal's most credible path forward lies in defining a clear role within the European semiconductor system

A Central Hypothesis

The analysis developed in this document leads to a central hypothesis that Portugal can achieve a durable and relevant position in the semiconductor industry by focusing on design, talent, and ecosystem formation, rather than attempting to replicate capital-intensive manufacturing models.

This hypothesis is not speculative. It is grounded in:

- empirical observation of past national experience
- comparison with successful international models
- identification of structural constraints and opportunities

Structure of the Document

The structure of this document encompasses:

1. Context and framing	The strategic importance of semiconductors and the structure of the value chain
2. Portugal's trajectory	Four decades of industrial and academic experience
3. Structural diagnosis	Identification of recurring patterns and systemic gaps
4. International benchmarking	Analysis of successful models (Taiwan, Israel, Ireland, Belgium)
5. Strategy and action	Definition of a focused, realistic path for Portugal within Europe

A Note on Perspective

The analysis presented here draws on publicly available information, and direct observation of the sector's evolution.

To preserve analytical clarity, the narrative focuses on structural mechanisms, system dynamics, and actionable insights.

Objective

The objective of this document is not to provide definitive answers, but to enable better decisions.

In a domain where investment cycles are long, technological complexity is high, and strategic windows are limited, clarity of direction becomes a decisive factor.

The purpose of this work is to contribute to that clarity.

Context and Framing

1

The Strategic Importance of Semiconductors

Why semiconductors have become a foundational technology for economic resilience, innovation, and geopolitical influence.

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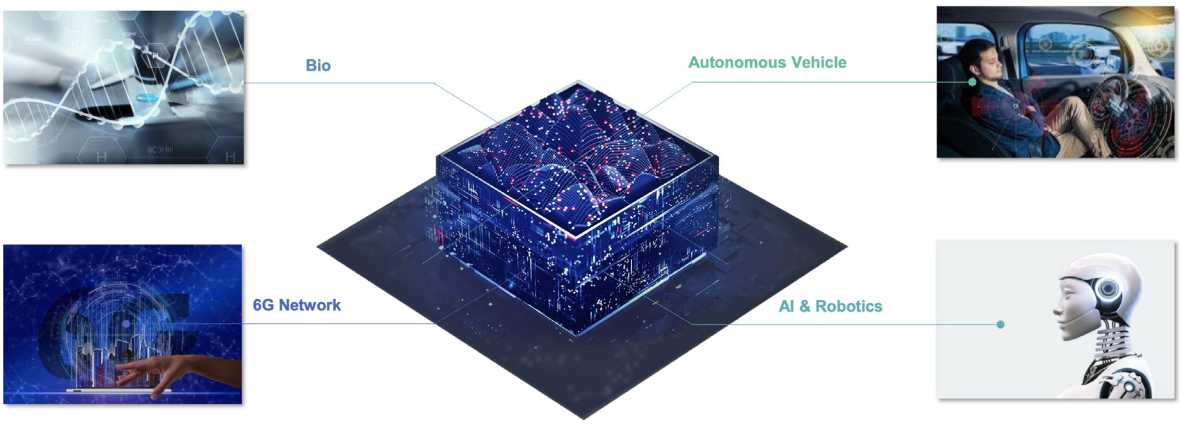
Semiconductors are not one industry among many, they are the foundational layer of all advanced industries.

They are the invisible infrastructure of the modern world.



Semiconductors as the foundational enabling technology for the major innovation domains of the 21st century, including artificial intelligence and robotics, autonomous vehicles, next-generation communications, and biotechnology.

1.1 The Foundational Layer of the Modern Economy

Every major economic sector is now semiconductor-dependent:

- Automotive systems integrate hundreds to thousands of chips per vehicle
- Data centres, the core infrastructure of the digital economy, are entirely semiconductor-driven
- Telecommunications, energy systems, healthcare equipment, and defense platforms rely on increasingly complex integrated circuits

Global semiconductor revenues exceeded **$500 billion annually** in recent years, but this figure understates their real impact. The true economic leverage of semiconductors lies in the **trillions of dollars of downstream industries they enable.**

As a result of its global presence in all sorts of activities, semiconductors are not a sector, they are a multiplier of all sectors.

1.2 Structural Dependence and Systemic Risk

The global economy is structurally dependent on a **highly concentrated semiconductor supply chain**.

Three characteristics define this system:

01
Extreme geographic concentration

- Advanced logic manufacturing is dominated by a small number of players, led by TSMC
- Critical equipment is largely controlled by a handful of firms, including European leaders
- Design capabilities are concentrated in the United States and parts of Asia

02
High barriers to entry

- A leading-edge fabrication facility requires investments exceeding $10–20 billion per site
- Technology development cycles span decades
- Ecosystem dependencies (materials, tools, talent) are deeply interlocked

03
Limited substitutability

- Chips are application-specific and not easily interchangeable
- Shortages in even low-cost components can halt high-value production systems

The clear consequence is that semiconductors constitute a systemic risk vector in the global economy.

This was demonstrated during the COVID-19 period, when semiconductor shortages led to:

- multi-billion-euro losses in the automotive sector
- production delays across multiple industries
- increased awareness of supply chain fragility at the highest policy levels

1.3 From Market Commodity to Geopolitical Asset

Over the past decade, semiconductors have transitioned from a market-driven industry to a **strategically contested domain**.

Governments now treat semiconductor capabilities as:

→ **critical infrastructure**

→ **national security assets**

→ **levers of geopolitical influence**

This shift is driven by three forces:

01 Technological acceleration

- Artificial intelligence, high-performance computing, and advanced communications are driving exponential demand for compute power
- Performance gains increasingly depend on specialised chip architectures

02 Supply chain vulnerability

- Over-reliance on limited geographic regions creates exposure to disruption

03 Strategic competition

- Major global actors are investing heavily to secure domestic capabilities and reduce dependency

1.4 Europe’s Position: Capable but Structurally Incomplete

Europe occupies a paradoxical position in the global semiconductor landscape.

Strengths

- Leadership in critical segments (notably equipment, automotive, and specific industrial applications)
- Strong scientific and engineering base
- Established industrial ecosystem (automotive, aerospace, energy)

Weaknesses

- Limited presence in advanced logic manufacturing
- Fragmented design ecosystem
- Insufficient scale in venture-backed semiconductor innovation

Europe’s share of global semiconductor manufacturing has declined significantly over the past decades, falling well below its historical position. This has led to a strategic response embodied in the European Chips Act.

1.5 The European Chips Act: Ambition and Constraints

The European Chips Act sets out clear objectives:

- to significantly increase Europe’s share of global semiconductor production
- to strengthen technological sovereignty and supply chain resilience

It mobilizes:

- tens of billions of euros in public and private investment
- coordinated action across member states
- support for research, design, manufacturing, and skills

However, two constraints must be acknowledged:

1. **Scale disadvantage**

   Europe is competing against regions that have invested consistently for decades

2. **Execution complexity**

   Semiconductor ecosystems cannot be built through isolated initiatives; they require sustained coordination across multiple layers

The implication is that success will depend less on funding volume and more on strategic coherence and execution discipline.

1.6 Portugal: A Non-Zero Starting Point

Portugal does not start from zero in semiconductors. It has accumulated, over several decades:

- Industrial experience through multinational operations
- A base of highly qualified engineering talent
- Recognised academic activity in microelectronics and related fields
- A notable success case in design and IP

However, these elements have not converged into a sustained, scalable ecosystem.

Instead, the historical pattern has been characterised by:

- episodic industrial presence
- limited value capture
- weak continuity between initiatives

This leads to the critical observation that Portugal has participated in the semiconductor industry, but has not shaped its position within it.

1.7 The Cost of Not Learning

The current wave of interest in semiconductors creates a window of opportunity. But without a structured understanding of past outcomes, this window risks closing without lasting impact. Historically, three failure modes have been recurrent:

- Attracting activity without anchoring it
- Generating knowledge without commercialising it
- Participating in global value chains without capturing strategic value

These are not accidental, they reflect underlying structural gaps. If these gaps are not explicitly addressed, increased investment alone will not change outcomes.

Repetition of past patterns is the default outcome in the absence of deliberate learning.

1.8 Objective and Approach of This Document

This document is built on a simple but demanding premise that effective strategy requires explicit learning from empirical evidence.

Its objective is therefore not to document history, but to interrogate it.

The approach is structured along three dimensions:

01

Empirical analysis of Portugal's trajectory

- Identification of key phases and initiatives
- Assessment of outcomes and discontinuities

02

Structural diagnosis

- Extraction of recurring patterns
- Identification of systemic constraints

03

Comparative benchmarking

- Analysis of countries that have achieved sustained success
- Isolation of transferable mechanisms

These elements converge into the final objective to define a focused, realistic, and actionable strategic model for Portugal.

1.9 Positioning and Intent

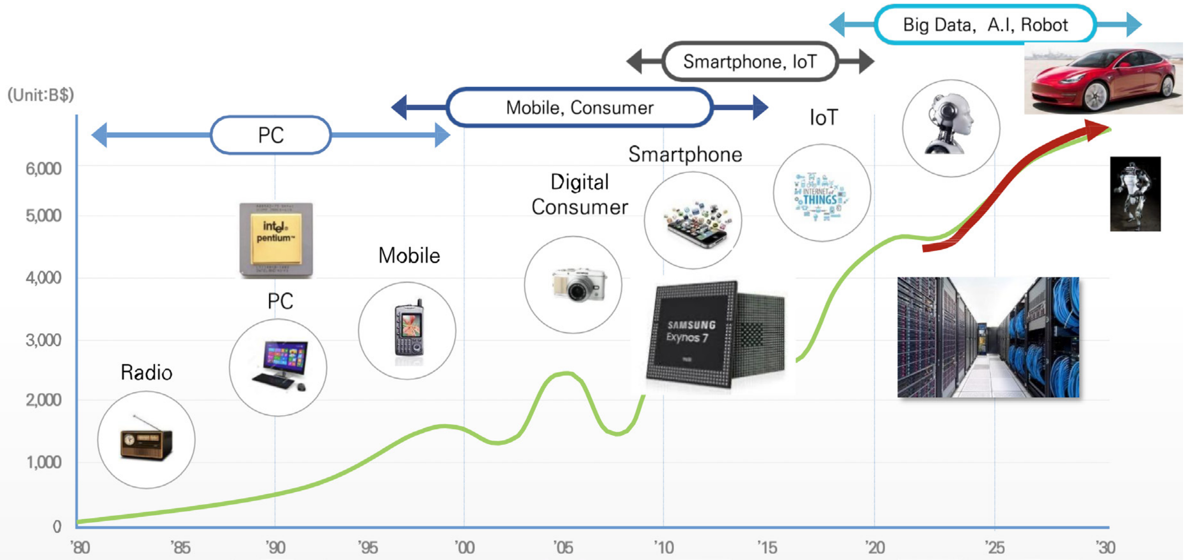
This work adopts a deliberately analytical and forward-looking perspective. It does not aim to provide exhaustive historical coverage nor offer neutral descriptions of events.

Instead, it aims to identify causal mechanisms, extract operational lessons, and support decision-making at policy and industry levels.

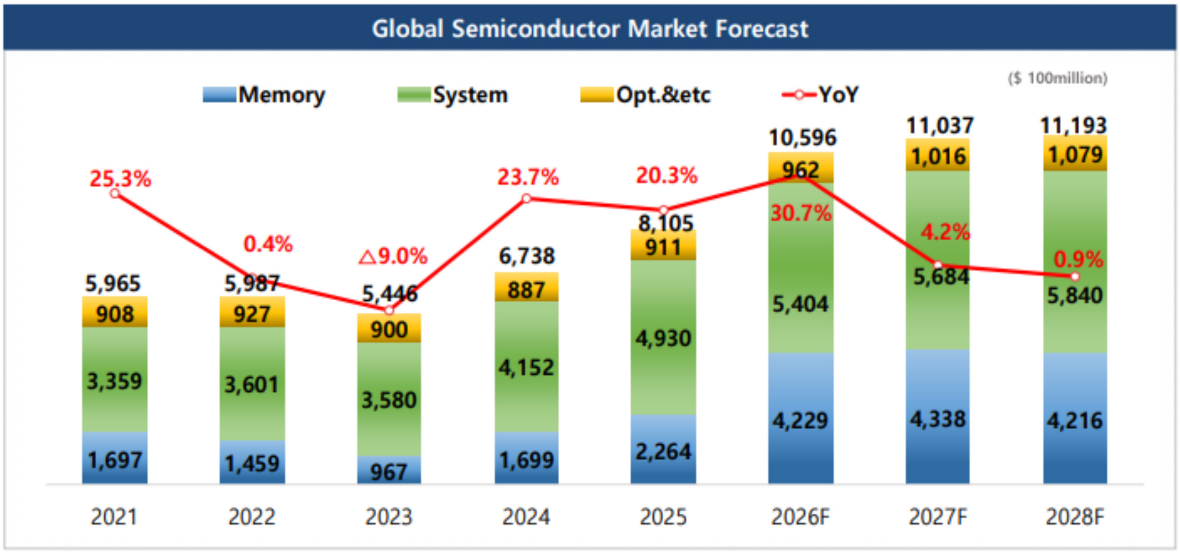
In a domain where technological cycles are long and strategic windows are limited, delayed clarity has tangible costs.

The purpose of this document is to reduce that delay.

Context and Framing



Major demand drivers of the semiconductor industry from 1980 to 2030. Each technological wave, from PCs and mobile devices to IoT, AI, autonomous vehicles, and robotics, has generated new semiconductor markets and sustained the long-term growth of the industry.



Projected evolution of the global semiconductor market by functional category. The dominant role of system semiconductors underscores the growing importance of design-intensive activities, an area in which Portugal has developed internationally recognised capabilities through its ecosystem of semiconductor design companies and engineering talent.

2

The Semiconductor Value Chain and the Strategic Positions of Nations

The first strategic question is not whether a country should participate in semiconductors. It is where in the value chain it can build a position that is credible, sustainable, and value-accretive.

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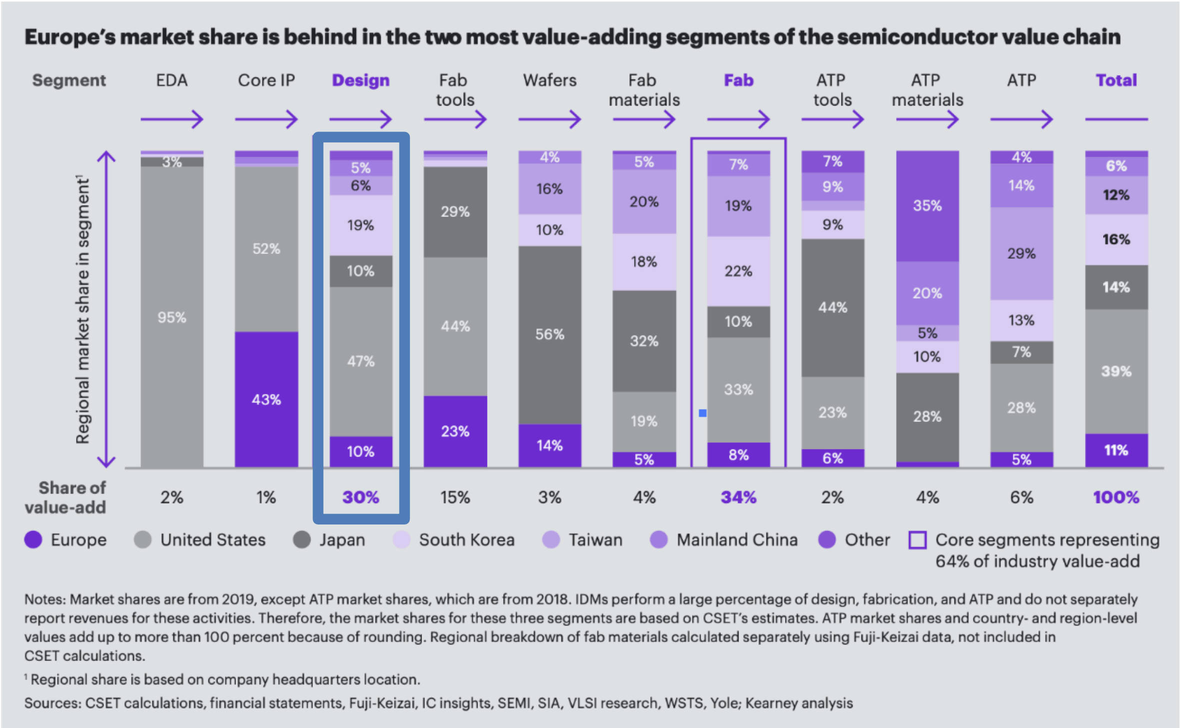
Portugal’s semiconductor opportunity is not to become everything. It is to become indispensable in something.

Countries succeed only when they identify the right layer, commit to it consistently, and build the mechanisms required to sustain it.



Regional distribution of semiconductor value capture. The largest share of industry value is generated in design- intensive segments such as chip architecture, intellectual property, and EDA software. The figure highlights the strategic importance of semiconductor design capabilities, which increasingly represent the primary source of competitive advantage within the global semiconductor ecosystem.

2.1 Why the Value Chain Matters

Any serious discussion of semiconductor strategy must begin with a basic discipline: **not all parts of the semiconductor industry are the same.**

The term semiconductor industry is often used as if it described a single coherent sector. It does not. It describes a **multi-layered value chain**, with very different economics, entry barriers, capital requirements, business models, and national competitiveness conditions.

This distinction is not academic. It is the starting point for sound policy.

Context and Framing

Countries fail in semiconductors when they treat the industry as a symbolic aspiration rather than as a **set of specific strategic positions**. They announce national ambitions without defining where in the value chain they intend to compete, what capabilities they possess, what scale is required, and what type of coordination is necessary. The result is predictable: fragmented initiatives, weak prioritisation, and limited durable impact.

The first strategic question is therefore not "should a country participate in semiconductors?"

It is instead where in the semiconductor value chain can that country build a position that is credible, sustainable, and value-accretive?

For Portugal, this question is decisive. The country does not have the scale, capital base, or industrial depth to participate meaningfully in all layers. It must choose.

2.2 The Semiconductor Value Chain: A Functional Decomposition

The semiconductor industry can be viewed as a sequence of interdependent layers, each creating value in a different way. At a simplified level, these layers include:

1. Research and early technology development
2. Chip design and architecture
3. EDA tools, IP blocks, and design infrastructure
4. Wafer fabrication
5. Assembly, packaging, and testing
6. Systems integration and application markets
7. Equipment, materials, and process technologies

These layers are tightly connected, but they are not equivalent in strategic logic.

Some are knowledge-intensive and talent-driven;

Some are capital-intensive and scale-driven;

Some are high-margin and defensible;

Some are operationally important but strategically vulnerable.

A country's role in semiconductors depends on where it enters this structure.

2.3 Research: Necessary, but Not Sufficient

At the beginning of the chain lies **scientific and technological research**. Universities, research institutes, and advanced laboratories generate knowledge in microelectronics, device physics, circuit design, lithography, packaging, process integration, and many adjacent areas.

This layer is indispensable. Without research, there is no long-term capability formation, no talent pipeline, and no future technological option value. However, research by itself is **not industrial positioning.**

This is one of the most important distinctions for countries with strong academic cultures but weaker industrial outcomes. Publications, doctoral theses, prototypes, and even internationally recognised scientific excellence do not automatically translate into economic value. The translation requires additional mechanisms:

- industrial relevance
- technology transfer structures
- entrepreneurial pathways
- capital formation
- strategic corporate engagement

Where these mechanisms are absent, research produces reputation but not industrial traction.

This distinction will be particularly relevant in the Portuguese case. Portugal has generated important scientific competence in areas related to semiconductors, but scientific strength has too often remained **upstream of commercialisation**, disconnected from durable industrial outcomes.

2.4 Design: The Highest-Leverage Position for Talent-Based Economies

Chip design is one of the most strategically attractive positions in the semiconductor value chain for countries that possess strong engineering talent but limited industrial scale.

Design includes multiple layers:

system architecture	digital design	analog and mixed-signal design	RF design	physical implementation	verification and validation	application-specific optimisation

Context and Framing

This layer creates value through **intellectual depth**, not through physical scale alone. A well-trained engineering team can create globally competitive products or reusable IP without owning fabrication plants. In economic terms, design is a layer where **human capital compounds**.

This is especially true in two segments:

- **fabless semiconductor companies**, which design chips and outsource manufacturing
- **semiconductor IP firms**, which create reusable design blocks licensed into broader ecosystems

These models dramatically reduce the need for direct capital investment in manufacturing infrastructure, while preserving access to high-value participation in the global chain.

For smaller countries, this is critical. **The design layer offers several advantages:**

01 **Lower capital intensity than fabrication**	World-class design organisations are expensive, but they do not require the tens of billions of euros associated with leading-edge fabs.
02 **Strong dependence on talent quality**	This benefits countries with excellent technical education and internationally competitive engineers.
03 **High knowledge density**	Design organisations generate spillovers into startups, multinationals, adjacent software sectors, and advanced education.
04 **Easier integration into global networks**	A design center can be embedded into multinational structures or startup ecosystems without requiring a fully domestic supply chain.

This does not mean design is easy. It requires years of training, deep domain knowledge, access to tools, discipline, and customer relevance. But compared with fabrication, it is structurally more accessible.

For Portugal, this distinction is fundamental. If the country seeks a credible long-term role in semiconductors, design is not just an option, it is the most natural strategic entry point.

This conclusion is not theoretical. It is already partially validated by Portugal's own experience, particularly through the emergence of advanced design capability linked to Chipidea and, later, Synopsys.

2.5 EDA and Semiconductor IP: Invisible but Highly Strategic Layers

Two layers within the design ecosystem deserve special attention: **EDA tools** and **semiconductor IP.**

EDA (Electronic Design Automation) provides the software infrastructure through which modern chips are conceived, simulated, verified, and prepared for implementation. Without EDA, advanced chip design is impossible. It is one of the most strategically concentrated layers in the entire industry.

Similarly, **semiconductor IP** refers to reusable design blocks, such as analog interfaces, processor cores, memory interfaces, communications modules and others, that can be integrated into larger chip designs. This is a highly scalable business model because value is created once and reused across many customers and products.

These layers have four important characteristics:

01 High technical defensibility

They are difficult to build and difficult to replace.

02 Strong margin potential

Well-positioned IP and software businesses can achieve attractive economics because their marginal reproduction cost is low relative to the knowledge embedded.

03 Ecosystem centrality

They sit at the heart of the design process and influence many downstream actors.

04 Talent concentration

Success depends heavily on the presence of a small number of deeply capable engineers and technical leaders.

This makes EDA and IP particularly relevant for countries that can build specialised pockets of excellence.

From a Portuguese perspective, this is not abstract. It directly touches the strongest historical example of national success in semiconductors: the ability to create value in advanced design and IP, rather than in commodity manufacturing. This is one of the strongest signals in the document's emerging argument. Portugal's semiconductor future, if it is to be globally relevant, is far more likely to be built around **design intelligence** than around **fabrication scale**.

2.6 Wafer Fabrication: The Most Visible Layer, and the Most Misunderstood

Wafer fabrication occupies a special place in semiconductor policy because it is highly visible, capital-intensive, geopolitically important, and symbolically powerful. It is also the layer that most governments instinctively associate with semiconductor sovereignty.

But visibility should not be confused with accessibility.

Fabrication, especially at the leading edge, is one of the most demanding industrial activities ever created. A state-of-the-art fab requires:

- multi-billion-euro capital commitments
- long time horizons
- process maturity accumulated over decades
- dense supplier ecosystems
- ultra-specialised talent
- stable access to water, energy, and logistics
- customer scale sufficient to support continuous utilisation

The economics are brutal. Underutilised fabs destroy capital. Yield problems wipe out margins. Technology lag rapidly erodes competitiveness. Scale is not an advantage here; it is often a prerequisite for survival.

This creates a major policy trap for smaller countries: fabrication is the most politically attractive layer to announce, but often the least realistic layer to build.

That does not mean fabrication is unimportant. On the contrary, it is essential to the global industry. But from the perspective of national strategy, countries must distinguish between:

- participating in fabrication through selected niches or legacy nodes
- and attempting to create a globally competitive advanced-fabrication position from scratch

These are entirely different ambitions.

For Portugal, the realistic conclusion is direct: the country does not currently possess the industrial, financial, or ecosystem conditions required to build a leading fabrication position. Any strategy based on that assumption would be aspirational rather than executable.

2.7 Assembly, Packaging, and Testing: Operational Relevance, Mixed Strategic Value

Assembly, packaging, and testing occupy an intermediate place in the value chain. Historically, these activities were often treated as lower-value manufacturing stages, more labor-intensive and less knowledge-dense than design or advanced fabrication. In many cases, they were the first layers to internationalise geographically.

This helps explain why countries such as Portugal could attract such operations in earlier semiconductor cycles. Compared with leading-edge wafer fabrication, packaging and testing were more mobile, more cost-sensitive, and more compatible with locations offering lower labor costs.

However, this layer must be treated with nuance. Traditional packaging has often delivered:

- employment
- manufacturing discipline
- some industrial know-how

But not necessarily:

- control over strategy
- strong local innovation spillovers
- high-margin global positioning

That said, the picture is changing. Advanced packaging has become much more strategically relevant in recent years, especially with the rise of:

- heterogeneous integration
- chiplets
- high-bandwidth interconnect architectures
- performance optimization beyond conventional node scaling

In this more advanced form, packaging becomes more knowledge-intensive, more differentiated, and more central to system performance.

This matters for countries evaluating future opportunities. Packaging is no longer automatically a low-value layer. But its attractiveness depends on where it sits on the technological spectrum.

For Portugal, this implies a distinction between two historical realities:

- earlier participation in more conventional industrial packaging-related activities
- potential future participation in more advanced packaging niches, but only if linked to stronger technological depth, customer relationships, and ecosystem integration

The lesson is clear: **not all packaging is strategically equal**

2.8 Systems, Applications, and Demand Pull

The semiconductor value chain does not end with chips. It is connected to downstream system markets: automotive, industrial automation, communications infrastructure, consumer electronics, defense, healthcare, energy, aerospace, AI computing, and many others.

These application domains matter because they generate **demand pull**. Countries with strong downstream industries can help shape semiconductor specialisation by articulating industrial needs, co-developing solutions, and creating reference markets.

This is one reason some regions achieve stronger semiconductor ecosystems than others: they are not only producing semiconductors, they are embedded in large, demanding, adjacent sectors.

Europe benefits from this logic in automotive and industrial domains. The United States benefits from it in cloud computing, defense, and advanced digital platforms. Israel benefits from defense, communications, and startup intensity. Taiwan benefits from manufacturing scale and ecosystem density.

Portugal has some downstream strengths, in automotive components, industrial technologies, telecom-related engineering, and selected digital sectors, but not at a scale sufficient, by itself, to drive a national semiconductor industry. This again suggests that the country's most credible role lies not in full-spectrum industrial autonomy, but in **specialised insertion into broader international systems**.

2.9 Why Small Countries Must Specialise

A small country cannot build a sustainable semiconductor strategy by attempting to reproduce the entire value chain. That is not strategic ambition; it is strategic indiscipline.

Semiconductors reward specialisation for three reasons:

1. The industry is too broad

No small economy can simultaneously build world-class capabilities in design, tools, process technology, fabrication, packaging, equipment, materials, and applications.

2. Capabilities are cumulative

Success requires long periods of focused investment, institutional memory, and iterative learning. Spreading effort too widely dilutes competence.

3. Global integration is normal

Even the most successful semiconductor countries do not internalize the full chain perfectly. They specialise, dominate selected nodes, and integrate internationally for the rest. This means the strategic task for smaller countries is not to maximize participation breadth. It is to maximize:

- relevance
- defensibility
- spillover potential
- strategic durability

The right question is therefore:

Which layers allow a country to create knowledge, capture value, develop talent, and remain globally connected over time?

For Portugal, the answer is unlikely to be broad-based industrial self-sufficiency. It is much more likely to be **focused excellence in selected layers**, especially those driven by talent, design know-how, research translation, and multinational integration.

2.10 The Strategic Positions Available to Portugal

Based on the structure of the value chain, Portugal's realistic strategic positions can be grouped into four categories.

01 Advanced design and semiconductor IP

This is the strongest candidate. It builds on engineering capability, creates high-value output, integrates well with multinational and startup ecosystems, and has already shown empirical viability in the Portuguese context.

02 Design-linked research and industrial collaboration

Portugal can strengthen the interface between academic research and industrial semiconductor needs, particularly in analog, mixed-signal, RF, embedded systems, and selected application domains.

03 Selected participation in packaging or industrial operations

This can be relevant where there is real technological depth and durable corporate anchoring. But this position is weaker if it depends only on cost-based attraction.

04 Internationally connected talent platforms

A country can create strategic value not only through companies, but also through institutions that produce, attract, and retain semiconductor talent at scale, while serving multinationals, startups, and collaborative research networks.

This last point is important. Talent is often treated as a support variable. In semiconductors, it is a strategic asset in itself. Countries that consistently produce scarce design talent can become indispensable nodes in global ecosystems even without dominating manufacturing.

This suggests a broader principle:

Portugal's semiconductor opportunity is not to become everything. It is to become indispensable in something.

2.11 What Portugal Should Avoid

A credible strategy is not only about what to do. It is also about what not to do. Portugal should avoid at least four strategic errors.

01
Confusing visibility with viability

Highly visible semiconductor activities, especially leading-edge fabrication, may be politically attractive but economically unrealistic.

02
Treating research as an end state

Scientific excellence is valuable, but without industrial translation it does not create a durable semiconductor position.

03
Relying only on transient multinational presence

Foreign investment matters, but if the country does not deepen local capabilities and embed firms over time, presence remains temporary.

04
Fragmenting effort across too many fronts

A semiconductor strategy without prioritisation becomes a list of aspirations rather than an execution framework.

These are not hypothetical risks. They are directly connected to patterns that have already appeared in Portugal's historical trajectory.

2.12 The Central Argument

The central argument here can be stated simply: The semiconductor industry is not one opportunity, but many distinct opportunities. Countries succeed only when they identify the right layer, commit to it consistently, and build the institutional and industrial mechanisms required to sustain it.

For Portugal, the implications are already visible.

The country's realistic path does not lie in attempting to replicate the full value chain, nor in pursuing symbolic semiconductor sovereignty detached from actual capabilities. It lies in building a **focused position in design, IP, research translation, and talent formation**, complemented where possible by selected industrial nodes that can be anchored durably.

This conclusion does not reduce ambition. It makes ambition credible.

2.13 Bridge to the Portuguese Historical Analysis

With this framework in place, the historical analysis of Portugal's semiconductor trajectory can now be interpreted more rigorously.

The key question in the discussions that follow is not simply what happened. It is:

→ In which parts of the value chain did Portugal participate?

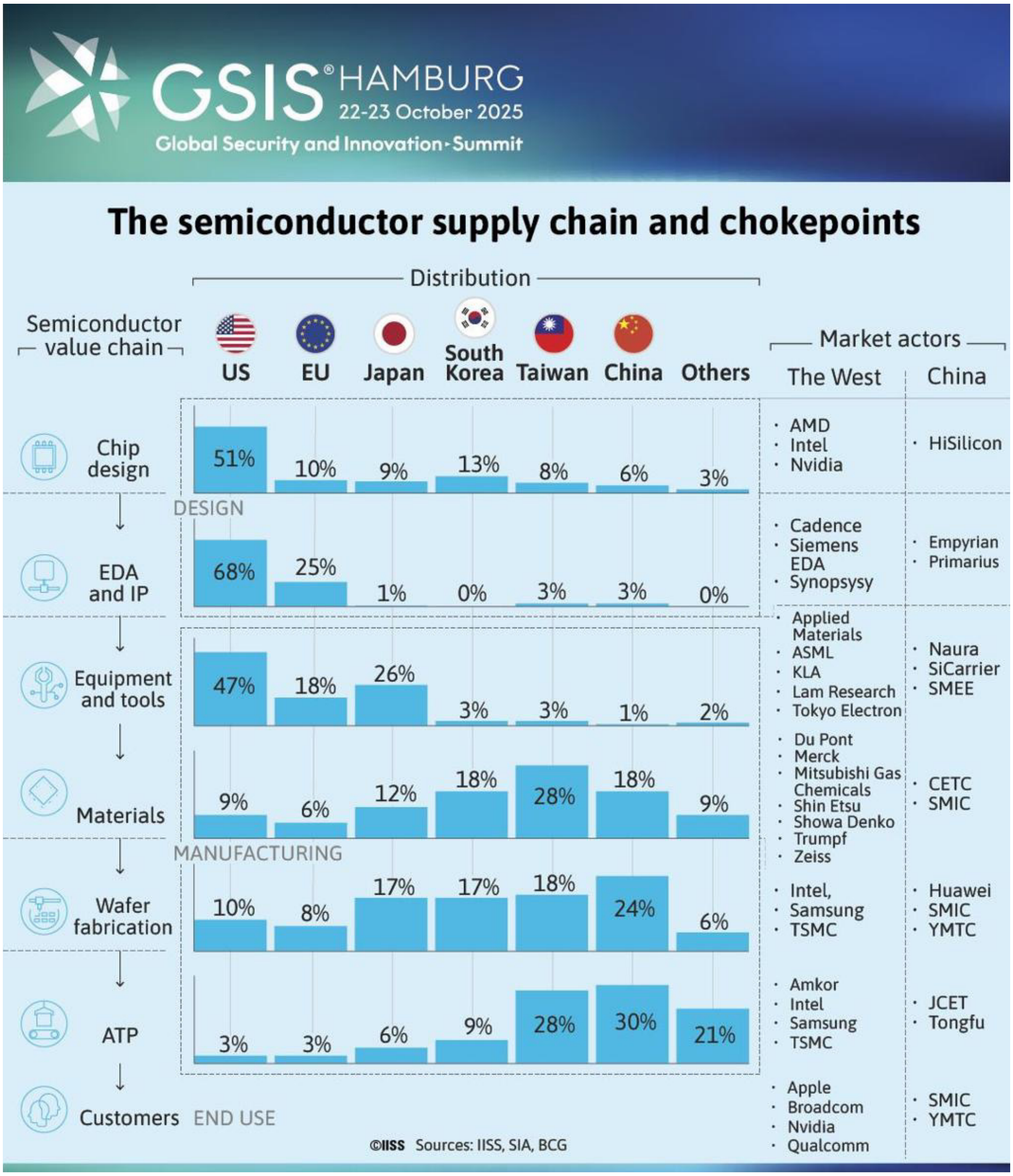
→ Under what conditions?

→ With what degree of control?

→ With what durability?

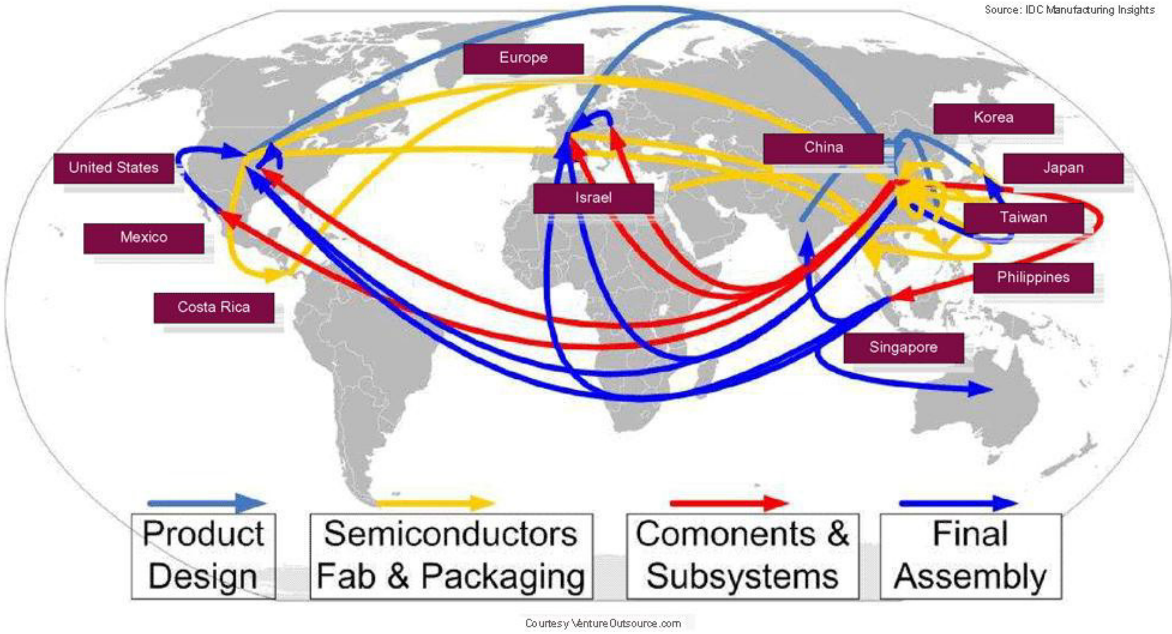
→ And with what capacity to capture long-term value?

Only by asking these questions can history become useful. That is the task next.

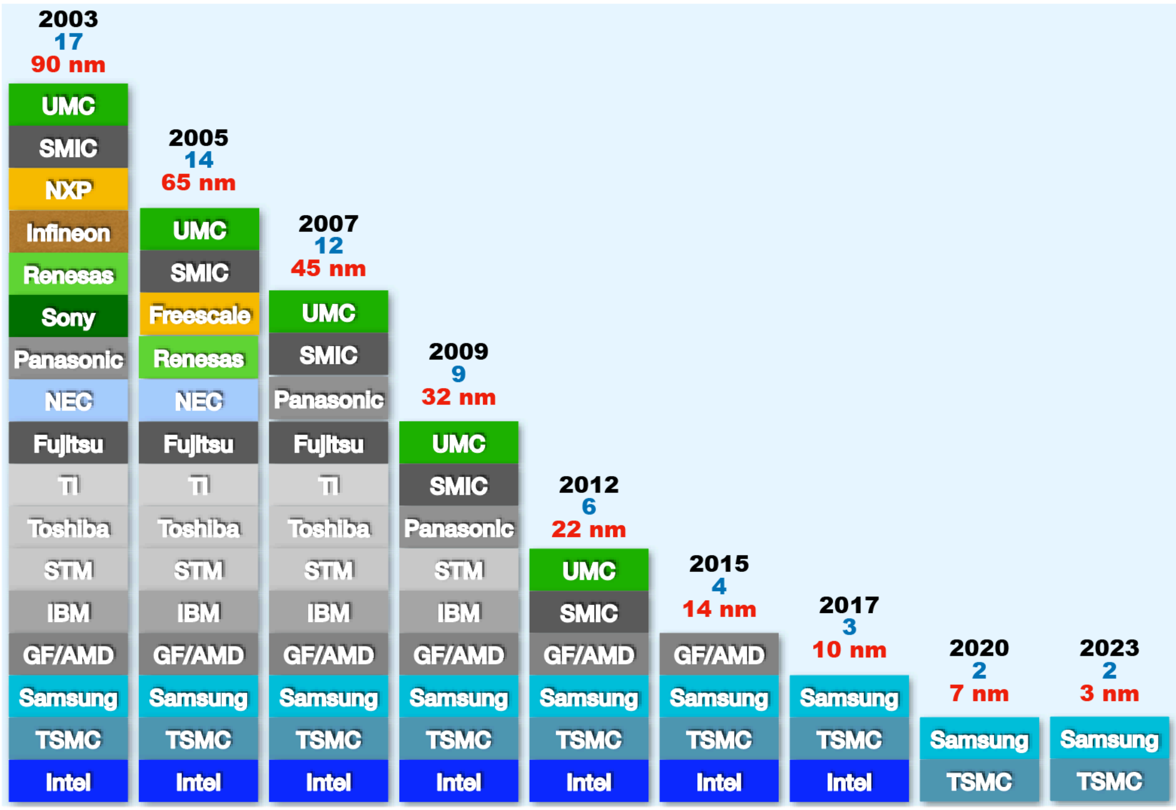


Global distribution of the semiconductor value chain and its strategic chokepoints. The highest-value and most defensible positions are concentrated in design, EDA software, IP, and advanced manufacturing technologies. Understanding where nations participate within this value chain is essential for defining realistic and sustainable semiconductor strategies, including for countries such as Portugal.

Context and Framing

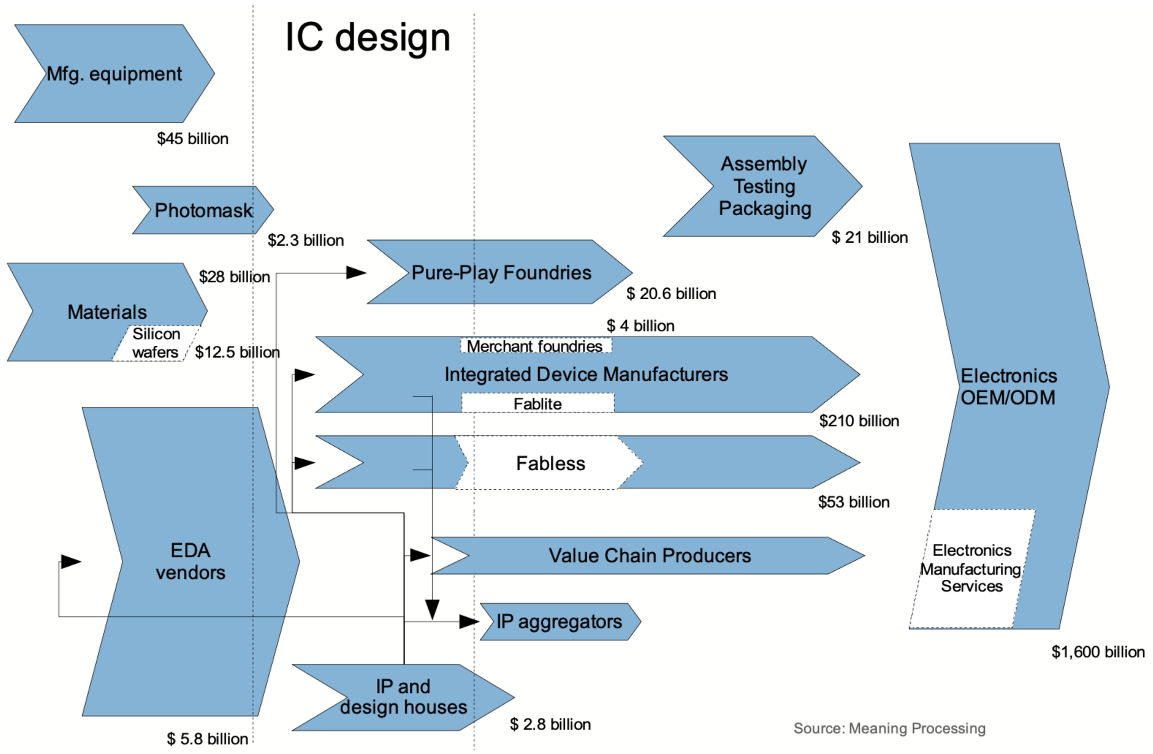


Global distribution of semiconductor value creation activities. The industry has evolved into a highly specialized international ecosystem in which design, manufacturing, packaging, testing, and system integration are performed across different regions of the world. This fragmentation has increased efficiency and innovation but has also created critical dependencies that influence industrial competitiveness, supply-chain resilience, and technological sovereignty.



Evolution of leading-edge semiconductor manufacturing and the corresponding consolidation of industry leadership. The growing complexity and capital intensity of advanced process technologies have transformed semiconductor fabrication into one of the most demanding industrial activities in the world, creating substantial barriers to entry for nations and companies alike.

Context and Framing



Source: Meaning Processing

Modularization of the semiconductor value chain and the rise of the fabless model. By separating chip design from manufacturing, the industry created opportunities for highly innovative design companies to compete globally without owning fabrication facilities. This transformation enabled the emergence of a new generation of semiconductor startups, including successful examples from Portugal.

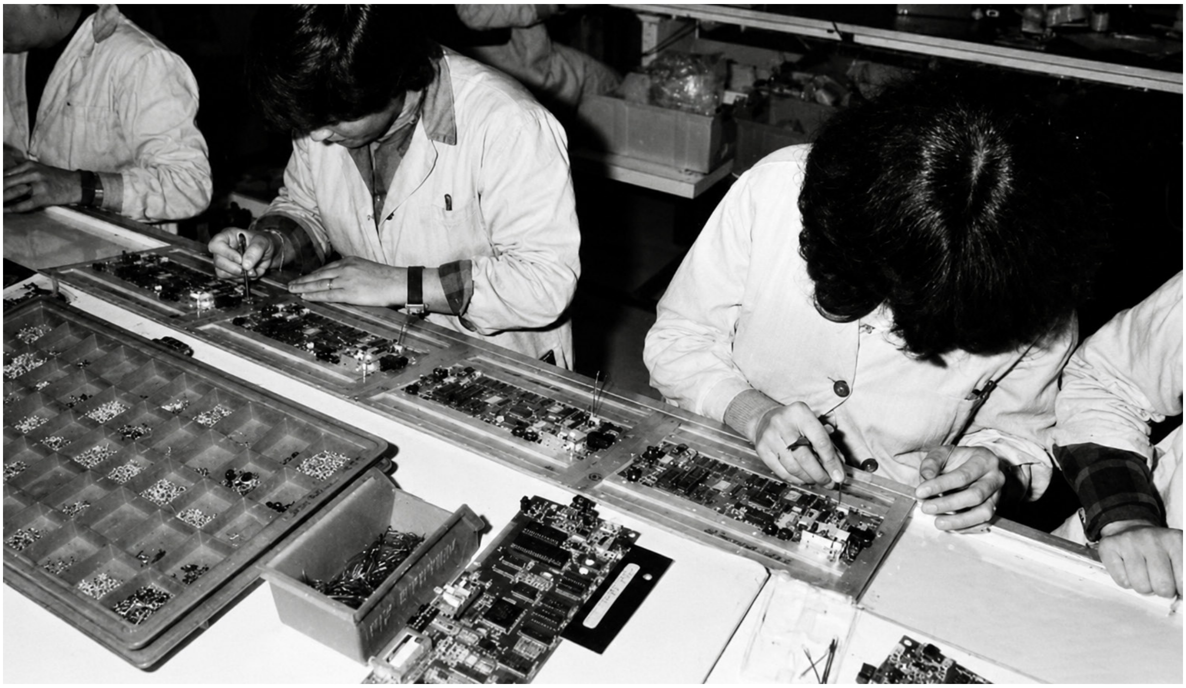
3

The First Wave: Entry Without Anchoring

The first participation in semiconductors created industrial activity, but not the capabilities required for lasting strategic positioning.

“

Portugal succeeded in entering the global semiconductor industry. It did not succeed in converting that entry into a sustained capability trajectory.



Electronics Assembly Operations in Portugal, 1980s

3.1 The Nature of Portugal's Initial Entry

Portugal's first meaningful participation in the semiconductor and electronics industry took place during the broader wave of industrial internationalisation in Europe in the late 1970s and throughout the 1980s.

This entry was not driven by domestic technological capability or indigenous entrepreneurship. It was driven by **foreign multinational corporations optimising global production networks**.

The industrial logic was clear and widely replicated across multiple geographies:

- relocation of labor-intensive activities
- cost optimisation within global supply chains
- proximity to European markets
- diversification of production locations

Portugal offered, at the time:

- competitive labor costs
- political stabilisation following the post-1974 transition
- increasing integration into European economic structures
- availability of a disciplined industrial workforce

These conditions enabled the country to position itself as a **host location for manufacturing and assembly operations**, including in electronics and semiconductor-related activities. However, this mode of entry had a defining structural limitation:

Portugal entered the semiconductor industry as a location, not as a strategic actor within the value chain.

3.2 Texas Instruments in Maia: A Prototypical Case

The establishment of operations by Texas Instruments in Maia represents one of the clearest examples of this first wave.

As a global leader in semiconductors, Texas Instruments operated across the full value chain, from design to manufacturing. Its presence in Portugal, however, was **functionally selective**.

Operational profile

- Focus on assembly and manufacturing-related activities
- Integration into a global production system
- Limited autonomy at the local level

Local impact

- Creation of industrial employment
- Introduction of quality processes and manufacturing discipline
- Initial exposure

Structural limitations

- No significant local R&D or design activity
- Limited engineering capability development
- Weak interaction with universities or research institutions
- Strategic decision-making remained external

The operation performed effectively within its assigned role. However, that role was structurally constrained to a **lower-value, mobile segment of the value chain**.

When global cost structures evolved, particularly with the emergence of more competitive locations, the economic rationale for maintaining such operations in Portugal diminished.

The result was a lack of long-term anchoring.

3.3 ITT Corporation and Standard Electric in Cascais

A parallel case is provided by the presence of ITT Corporation through its Standard Electric operations in Cascais.

Like Texas Instruments, ITT was a large multinational integrating global operations across telecommunications and electronics. Its Portuguese activities followed a similar pattern.

Operational profile

- Manufacturing and assembly functions
- Integration into international supply chains

Local contributions

- Employment generation
- Development of operational industrial capabilities

Portugal's trajectory

Structural constraints

- Limited technological upgrading within Portugal
- Minimal local influence over strategic direction
- Weak integration with domestic innovation systems

Once again, the pattern is consistent:

- entry driven by external corporate optimization
- positioning in cost-sensitive segments
- absence of a structured upgrading trajectory
- eventual decline or exit as global conditions shifted

3.4 The Economics of Cost-Based Positioning

The outcomes observed in these cases are not incidental, they are the direct consequence of the underlying economics.

Cost-based location strategies exhibit three structural properties:

01

Convergence over time

As host countries develop, wages rise and cost advantages erode.

02

Continuous global competition

New regions enter global manufacturing networks with more competitive cost structures.

03

High mobility of activities

Assembly and lower-value manufacturing can be relocated with relatively low friction.

This leads to a fundamental principle:

Competing on cost in mobile segments of the value chain leads to inherently unstable positioning.

Portugal's initial semiconductor presence was built precisely on this basis. Without a transition to higher-value activities, stability could not be achieved.

3.5 The Missing Strategic Layer: From Attraction to Upgrading

Portugal's ability to attract major multinational corporations such as Texas Instruments and ITT Corporation demonstrates that the country was capable, even at that stage, of integrating into global industrial networks.

However, attraction is not strategy. It is an entry point.

The critical issue is whether that entry point is used to build a **trajectory of upgrading**, moving progressively:

- from manufacturing to engineering
- from engineering to design
- from design to strategic control

In Portugal's case, this trajectory was not systematically pursued.

This reflects the absence, at the time, of a **clearly articulated medium- to long-term vision** regarding the country's role in high-technology sectors such as semiconductors.

Three dimensions of this absence are particularly relevant:

01
No explicit positioning within the value chain.

There was no clear national objective defining:

- which layers Portugal should aim to develop
- how initial industrial presence could evolve into higher-value activities

02
Underutilisation of multinational presence as a strategic lever

The presence of large corporations was not systematically leveraged to:

- negotiate progressive upgrading of activities
- develop local engineering capabilities
- stimulate supplier networks or entrepreneurial spin-offs

03
Weak coordination across institutions

There was no integrated framework aligning:

- industrial policy
- higher education
- research institutions
- long-term capability development

“

Portugal entered the semiconductor industry as a location

not as a strategic actor within the value chain.

”

3.6 A Counterfactual: What a Strategic Approach Might Have Looked Like

International experience shows that multinational presence can be used as a **catalyst for capability formation**, rather than as an isolated industrial outcome.

A more strategic approach in Portugal could have included:

- development of engineering programs aligned with industry needs
- structured partnerships between companies and universities
- incentives linked to **capability upgrading**, not only job creation
- support for local entrepreneurship emerging from industrial experience
- long-term engagement frameworks with multinational firms

The objective would not have been to prevent eventual restructuring, this is often unavoidable, but to ensure that, over time, the country accumulated **transferable capabilities and strategic depth**.

3.7 Human Capital: Exposure Without Compounding

The first wave did generate one important asset: initial human capital exposure. Workers gained experience in:

- electronics manufacturing
- quality systems
- industrial processes

However, two limitations constrained long-term impact:

- limited exposure to high-value engineering and design activities
- absence of a sustained ecosystem capable of retaining and upgrading this talent

As a result, human capital formation remained shallow and non-cumulative.

This stands in contrast to later phases, where design-oriented activities would demonstrate much stronger compounding effects.

3.8 Reinterpreting the First Wave

With the analytical framework established in 2, the first wave can be interpreted more precisely.

Portugal participated in the semiconductor value chain:

- at lower-value, mobile segments
- under external strategic control
- without a defined pathway to **higher-value positioning**

This leads to a critical reframing:

The first wave was not a failure of attraction, it was a failure of transformation.

Portugal succeeded in entering the global semiconductor industry. It did not succeed in converting that entry into a **sustained capability trajectory**.

3.9 The First Structural Pattern

This phase establishes the first recurring pattern of Portugal's semiconductor history:

→ Entry through multinational presence

→ Positioning in cost-sensitive activities

→ Weak ecosystem integration

→ Absence of upgrading mechanisms

→ Lack of long-term anchoring

This pattern can be summarised as **Entry Without Anchoring**.

3.10 Implications for Current Strategy

The lessons from this phase are directly applicable to the present.

01	**Attraction is necessary but insufficient**	Industrial presence must be treated as a starting point, not an objective.
02	**Value chain positioning is decisive**	Long-term impact depends on entering and evolving toward higher-value layers.
03	**Anchoring requires deliberate policy**	Without structured mechanisms, operations remain transient.
04	**Vision must precede execution**	A clear medium to long-term positioning is essential to guide decisions and investments.

3.11 Transition to the Next Phase

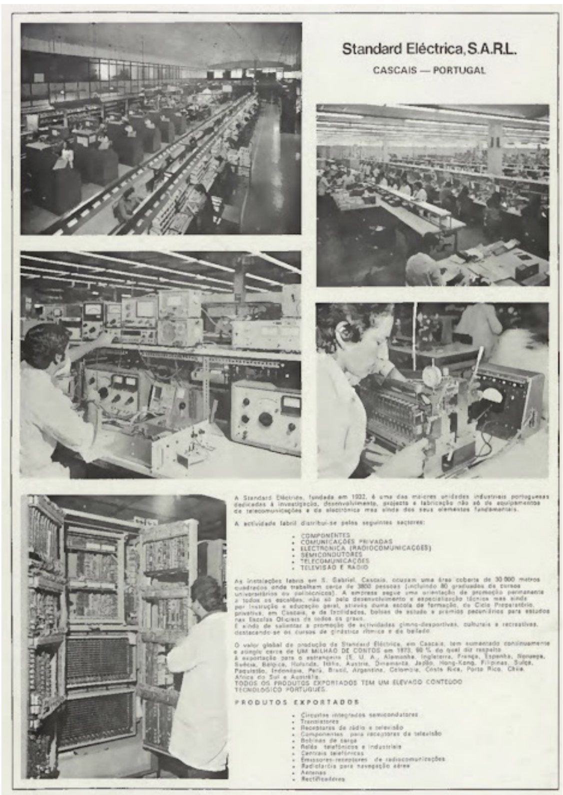
The first wave established Portugal's initial connection to the semiconductor industry but did not generate a durable strategic position.

The next phase, analysed in 4, introduces a more complex dynamic:

- higher technological sophistication
- greater industrial capability
- but still limited control over strategic assets

This marks an evolution: **from entry without anchoring to capability without control**

Portugal's trajectory



Standard Eléctrica's industrial facilities in Cascais, 1974 and 1982. The operation marked an important first step in Portugal's participation in the global electronics industry and demonstrated the country's ability to attract multinational electronics operations. However, technological capabilities and decision-making centres remained largely external, limiting the development of a sustainable national technology ecosystem and enduring semiconductor and electronics competencies.

Texas Instruments integrated circuit manufactured in Portugal. The "Portugal" marking reflects the country's successful participation in semiconductor production activities. However, while such operations generated industrial capacity and export revenues, the associated design, technology development, and strategic decision-making largely remained outside the country.

4

Industrial Upgrading Without Control

Upgrading in capability does not automatically translate into control over outcomes.

“

Portugal contributes capability,

but does not determine destiny.

A key distinction emerges across all phases: Portugal has repeatedly achieved presence, but not always positioning.

The Vila do Conde semiconductor complex under Infineon and Qimonda ownership. Unlike earlier experiences in the Portuguese electronics industry, this operation developed capabilities, talent, and industrial continuity that persisted across successive generations of companies, ultimately contributing to the emergence of a sustainable semiconductor manufacturing presence in Portugal, albeit under external control.

4.1 Industrial Upgrading Without Control

Following the initial wave of multinational-driven industrial entry, Portugal experienced a second phase characterised by higher technological sophistication and deeper industrial involvement in semiconductor-related activities.

This phase, emerging primarily in the 1990s and 2000s, differed from the first wave in several important respects:

- greater technological complexity of operations
- increased process knowledge and industrial discipline
- stronger integration into global semiconductor supply chains

Portugal was no longer only a host for basic assembly. It began to participate in more advanced industrial segments, particularly in areas related to semiconductor manufacturing and packaging.

However, despite this upgrading, a fundamental limitation persisted: **Portugal did not control the strategic direction of the activities taking place within its territory.**

4.2 Infineon Technologies: Industrial Depth Without Strategic Autonomy

The presence of Infineon Technologies marked a significant step forward in terms of industrial capability. Infineon, as a major European semiconductor company, brought:

→ advanced process technologies

→ integration into higher-value segments of the industry

→ exposure to global manufacturing standards

What changed relative to the first wave

- operations were more technologically demanding
- workforce skill requirements increased
- industrial processes were more sophisticated

What did not change

- strategic control remained external
- key decisions were taken at corporate headquarters
- local activities were still part of a broader global optimisation strategy

Portugal's role evolved - but it remained subordinate within the global value chain.

4.3 Qimonda: Systemic Vulnerability

The transition from Infineon to Qimonda illustrates a second critical dimension: **exposure to global industry cycles and corporate restructuring.**

Qimonda, created as a carve out of the memory business unit of Infineon operated in one of the most volatile segments of the industry - the memory market, which is characterised by:

→ extreme capital intensity

→ cyclical oversupply and price collapses

→ intense global competition

Portugal’s trajectory

The eventual collapse of Qimonda was not specific to Portugal, it was a **global corporate failure** driven by industry dynamics. However, its local impact was immediate and unavoidable. Portugal bore the consequences of decisions and outcomes over which it had no influence.

This reveals a structural vulnerability:

- When activities are not locally controlled,
- their continuity depends on external corporate and market forces.

4.4 Nanium: Local Continuity Emerges

With the collapse of Qimonda, it was possible, with the support of the Portuguese government and leading local banks, to isolate the local operation in Portugal giving rise to the emergence of Nanium. This represented a partial break from the previous pattern.

Nanium introduced two important elements:

1. Local entrepreneurial initiative

→ creation of a company with Portuguese roots

→ development of internal capabilities

2. Focus on advanced packaging

→ participation in a segment with increasing technological relevance

→ movement toward higher-value industrial activities

This marked a qualitative shift: for the first time, Portugal demonstrated the ability to sustain an industrial activity beyond the direct control of a multinational parent. However positive, this development must be interpreted carefully given the fact that Nanium inherited some of the most interesting activities and key corporate relationships of Qimonda.

4.5 Amkor Technology: Integration into Global Scale

The acquisition of Nanium by Amkor Technology - one of the largest global players in semiconductor packaging - introduced a new phase.

Positive effects

→ access to global customer base

→ integration into large-scale industrial operations

→ reinforcement of technological capabilities

Structural implications

→ reabsorption into a multinational structure

→ strategic direction defined externally

→ local autonomy constrained

This reflects a recurring pattern: local capability creation followed by integration into global corporate systems.

While this can be positive from an operational and technological standpoint, it raises a central question: to what extent does local capability translate into **long-term strategic positioning?**

4.6 Upgrading Without Control: The Core Mechanism

The Infineon → **Qimonda** → **Nanium** → **Amkor**

trajectory reveals a clear structural mechanism:

- Portugal moves into more advanced industrial activities
- Capabilities increase
- Workforce skills deepen
- Technological sophistication improves

But:

→ ownership remains external

→ strategic decisions are not local

→ long-term direction is not controlled domestically

4.7 Why Control Matters

Control is not an abstract concept, it determines:

- investment decisions
- activity allocation across geographies
- upgrading trajectories
- survival during downturns

When control is external:

- local operations are evaluated within a global portfolio
- decisions are optimised at the corporate level, not at the national level
- local ecosystems have limited influence over strategic outcomes

This creates a structural asymmetry:

Portugal contributes capability, but does not determine destiny.

4.8 Partial Progress: What This Phase Achieved

Despite its limitations, this phase represents real progress relative to the first wave.

1.	**Higher technological content**	Operations were significantly more advanced.
2.	**Stronger industrial capabilities**	Workforce skills and process knowledge improved.
3.	**Emergence of local initiative**	Nanium demonstrates that capability can translate into entrepreneurial action.
4.	**Integration into global supply chains**	Portugal became part of more sophisticated industrial networks.

These are not negligible achievements. They form part of the foundation on which future strategies can build.

4.9 The Structural Limitation

However, the central limitation remains: capability development was not matched by strategic control or systemic anchoring

This has two consequences:

1. **Vulnerability to external shocks**
- corporate restructuring
- industry cycles
- global optimisation decisions

2. **Limited accumulation of national advantage**
- capabilities exist, but are not fully leveraged at the ecosystem level
- spillovers remain constrained

4.10 The Second Structural Pattern

This phase establishes the second recurring pattern in Portugal's semiconductor trajectory:

- industrial upgrading occurs
- capabilities deepen
- local initiatives emerge

But:

→ control remains external

→ long-term outcomes remain uncertain

This pattern can be summarised as: **Capability without control**

4.11 Implications for Strategy

This phase adds a critical layer to the lessons derived from 3.

01	**Upgrading is necessary, but not sufficient**	Moving up the value chain is essential, but it does not guarantee strategic positioning.
02	**Ownership and control shape outcomes**	Without influence over strategic decisions, local capabilities remain vulnerable.
03	**Local initiatives must be scaled**	Entrepreneurial efforts such as Nanium are important, but need systemic support to become anchors.
04	**Integration must be leveraged**	Participation in global systems should be used to build local leverage, not only operational presence.

4.12 Transition to the Next Phase

The first two phases of Portugal’s semiconductor trajectory reveal a progression:

Phase 1: Entry without anchoring **Phase 2:** Capability without control

The next phase introduces a fundamentally different dynamic: the emergence of design and intellectual property as a strategic lever.

This will be analysed in 5, through the case of Chipidea.

For the first time, Portugal will demonstrate:

→ control over high-value activities

→ global competitiveness in a knowledge-intensive segment

→ and durable impact on talent and ecosystem formation

Portugal's trajectory

Semiconductor wafer processing in a cleanroom facility. Advanced wafer fabrication constitutes the technological core of semiconductor manufacturing and remains concentrated in a limited number of countries and companies due to its extraordinary complexity, scale, and capital requirements. This marks a fundamental distinction between Front-end manufacturing (wafer fabrication), which is highly capital- intensive, technology-driven, and concentrated in a few global players, and Back-end manufacturing (assembly, packaging, and test), where Portugal historically developed significant industrial activity through TISEP, Infineon, Qimonda, Nanium, and now Amkor.

Representative advanced semiconductor assembly and test facility. The increasing automation of packaging and testing operations illustrates the technological evolution of the manufacturing capabilities developed in Portugal through companies such as Qimonda, Nanium, and later Amkor.

5

The Design Breakthrough: Chipidea and Its Legacy

For the first time, Portugal demonstrated that it could originate, not just host, semiconductor value creation.

“

Portugal can participate in semiconductors through design-led positioning, rather than capital-intensive manufacturing.

The Chipidea case is not only a success story, it is a validated strategic model.

Portugal's trajectory

Development of semiconductor design activities in Portugal from 1997 to 2026. Over nearly three decades, the sector expanded from a single startup to a broader ecosystem comprising multinational design centres and specialized technology companies employing more than 1,000 professionals. This evolution has established sustainable foundations for future growth, positioning Portugal as an increasingly relevant contributor to the European semiconductor ecosystem.

5.1 A Structural Inflection Point

Until the mid-1990s, Portugal's participation in the semiconductor industry had been defined by two structural patterns:

→ **Entry without anchoring (3)**

→ **Capability without control (4)**

Both patterns shared a common limitation: **Portugal did not control high-value activities within the semiconductor value chain.**

Portugal’s trajectory

The emergence of Chipidea represents a fundamental break with this trajectory.

For the first time, Portugal:

- operated in a high-value segment (design and IP)
- exercised strategic control over core assets
- generated globally competitive technology from within the country

This was not an incremental improvement. It was a change of paradigm.

5.2 The Strategic Choice: Design Instead of Manufacturing

Chipidea’s model was based on a critical strategic choice: to compete in semiconductor design and intellectual property, rather than in manufacturing.

This choice aligned with structural realities identified in 2:

→ fabrication is capital-intensive and scale-driven

→ design is knowledge-intensive and talent-driven

By focusing on analog and mixed-signal IP, Chipidea positioned itself in a segment characterised by:

→ high technical barriers

→ strong demand across multiple applications

→ reusability of design blocks

→ global scalability without physical manufacturing assets

This positioning was not only technologically sound, it was strategically optimal for a country like Portugal.

5.3 Building a Company from a Non-Existing Base

At the time of Chipidea's creation, Portugal effectively had no established industrial base in integrated circuit design.

This makes the subsequent trajectory particularly significant. From an initial condition close to zero, Chipidea:

- built advanced design capability
- developed commercially viable semiconductor IP
- integrated into global customer networks
- demonstrated that world-class design could be executed from Portugal

This required:

- highly specialised talent formation
- disciplined engineering processes
- deep integration with global semiconductor ecosystems

The importance of this phase cannot be overstated. It established that Portugal could originate, not just host, semiconductor value creation.

5.4 The IP Business Model: Scalable Value Creation

A central element of Chipidea's success was its focus on the **semiconductor IP business model**. This model differs fundamentally from traditional manufacturing:

- value is created through design once, reuse many times
- marginal cost of replication is low
- revenue scales with customer adoption

In economic terms, this creates:

→ high value density per engineer
→ strong scalability without proportional capital investment
→ global reach from a local base

This is particularly relevant for smaller economies.

IP-based models allow countries with strong talent but limited capital to participate at the highest levels of the value chain.

5.5 Global Integration and Validation

Chipidea's integration into the global semiconductor ecosystem culminated in its acquisition by MIPS Technologies, and subsequently by Synopsys.

This sequence is significant for several reasons:

1.	**Market validation**	the company achieved global recognition of its technological and commercial value
2.	**Ecosystem integration**	its capabilities became embedded within leading global platforms
3.	**Continuity of activity**	semiconductor design activities not only continued in Portugal but expanded significantly

This contrasts sharply with earlier phases: instead of disappearance or decline, the activity scaled and deepened.

5.6 Talent Formation and Critical Mass

One of the most important outcomes of the Chipidea trajectory is the creation of a large-scale design talent base.

From effectively zero engineers in the mid-1990s, Portugal reached more than 1,000 engineers involved in integrated circuit design by 2026.

1,100+
IC Design Engineers
(2026)

≈ 900	associated with Synopsys in Portugal
≈ 200+	startups, smaller design houses, multinational design centres

Portugal's trajectory

This represents a structural transformation:

- talent is now present, trained, and experienced
- knowledge is cumulative and self-reinforcing
- the ecosystem begins to exhibit **critical mass dynamics**

This is the first time in Portugal's semiconductor history that capability formation has translated into sustained scale.

5.7 Spillovers: The Emergence of a Design Ecosystem

Two additional examples further illustrate the spillover effects generated by the emergence of the Portuguese IC design ecosystem.

Acacia Semiconductors originated from engineers previously associated with Chipidea. Although the operation itself never reached large scale, its trajectory is structurally important because it demonstrates the persistence and international integration of Portuguese design capability across multiple corporate transitions.

The Portuguese engineering operation was successively integrated into:

- S3 Group (Ireland)
- Adesto Technologies (United States)
- Dialog Semiconductor (Germany/United Kingdom)
- Renesas Electronics (Japan)
- Omni Design (USA)

Throughout these successive acquisitions, the engineering center located at the NOVA FCT campus was maintained and reinforced. This continuity is significant:

the value of the Portuguese operation resided not in low-cost labor, but in accumulated design expertise and specialized talent.

Today, this operation remains one of the relevant stakeholders in Portugal's growing IC design ecosystem, demonstrating that high-value semiconductor activities developed locally can survive repeated global restructuring cycles.

Another important example is SiliconGate, also founded by former Chipidea engineers. Although relatively small in scale (approximately 30 engineers), the company successfully specialized in power management integrated circuits, an area requiring deep analog and mixed-signal expertise.

Portugal's trajectory

Its recent acquisition by Celera Semiconductor (USA) further reinforced Portugal's growing role in the formation of highly specialized IC design talent for the global semiconductor industry. Its trajectory demonstrates another important characteristic of successful semiconductor ecosystems: small, highly specialized design companies can achieve global relevance through technical excellence in narrowly defined domains.

Together, these examples reinforce the essential point that Chipidea was not merely an isolated corporate success. It acted as a catalytic platform for talent formation, entrepreneurial diffusion, and the creation of new globally integrated semiconductor design activities in Portugal. It generated **second-order effects** that are essential for ecosystem formation:

1. **Entrepreneurial spillovers**
   - creation of startups by former engineers
   - diffusion of design expertise into new ventures
2. **Talent circulation**
   - movement of engineers across companies and projects
   - strengthening of the overall knowledge base
3. **Institutional influence**
   - stronger links with universities
   - influence on curricula and training
3. **International visibility**
   - Portugal recognized as a credible location for semiconductor design

This is the beginning of a **self-reinforcing ecosystem**, rather than isolated activity.

5.8 Control and Anchoring: A Different Outcome

Unlike previous phases, the Chipidea trajectory achieved a degree of anchoring, even after acquisition.

This is a critical distinction. While ownership transitioned to global companies:

- the core activity (design) remained in Portugal
- the talent base continued to grow
- the strategic importance of the local operation increased

Portugal's trajectory

This reflects a deeper structural reality:

High-value, talent-intensive activities are less mobile than cost-based manufacturing.

Once a critical mass of design capability is established:

- relocation becomes more difficult
- local ecosystems gain resilience
- multinational presence becomes more embedded
- indispensability becomes a reality

5.9 A Delivered Model for Portugal

The Chipidea case is not only a success story, it is a **validated strategic model**.

It demonstrates that Portugal can:

→ build world-class capability in a high-value segment

→ integrate into global semiconductor ecosystems

→ create scalable economic value

→ generate and retain highly skilled talent

→ stimulate the emergence of startups and new initiatives

→ define its indispensability in the global value chain

Most importantly, **it shows that:** Portugal can participate in semiconductors through design-led positioning, rather than capital-intensive manufacturing.

5.10 Implications for Europe

This model is not only relevant at the national level. It directly addresses a recognised structural gap in Europe:

- strong research base
- strong industrial sectors
- but insufficient scale in semiconductor design ecosystems

By developing design capability:

- Portugal contributes to strengthening Europe's position
- aligns with strategic priorities such as those of the European Chips Act
- complements manufacturing-focused initiatives in other regions

This reinforces the broader argument that Europe does not need every country to do everything, it needs each country to excel in specific, complementary layers.

5.11 The Third Structural Pattern

The Chipidea trajectory establishes a third pattern in Portugal's semiconductor evolution:

→ entry into high-value segments

→ local control over core capabilities

→ global validation and integration

→ sustained talent formation and ecosystem emergence

This pattern can be summarized as Control with Scalability.

5.12 Transition to Structural Analysis

With this third pattern established, Portugal's semiconductor trajectory can now be interpreted across three phases:

1. **Entry without anchoring**
2. **Capability without control**
3. **Design-led control and ecosystem formation**

The next step is to move from case analysis to structural diagnosis:

- Why did the first two patterns fail to produce durable outcomes?
- Why did the third succeed?
- What underlying mechanisms explain these differences?

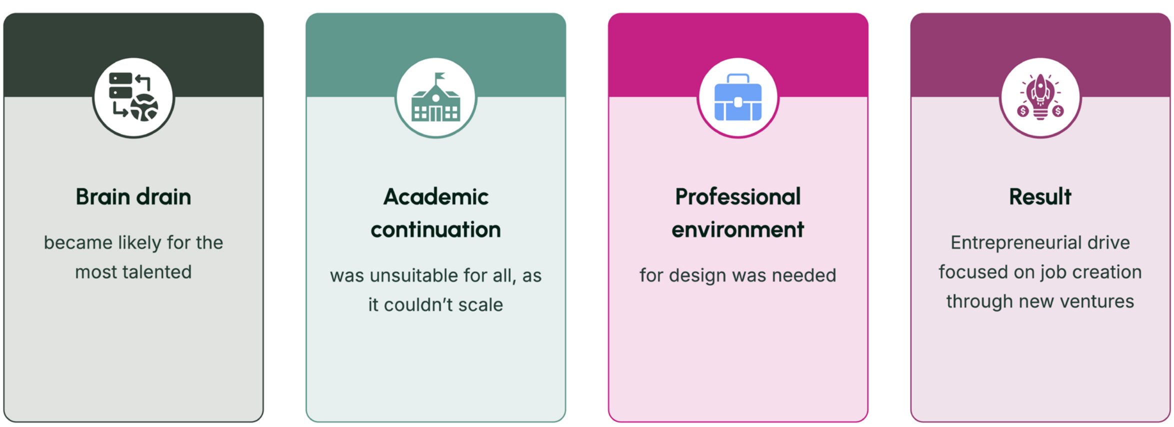
These questions will be addressed next.

Portugal’s trajectory

The Starting Point: A Strong IC Design Research Team.

The origins of Portugal’s IC design ecosystem. A strong academic research base in analog and mixed-signal circuits enabled the formation of highly qualified design engineers and the achievement of international recognition. The remaining challenge was to transform scientific excellence into sustainable industrial opportunities within Portugal.

The Trigger Problem



The catalyst for ecosystem creation. While Portugal had succeeded in developing internationally recognized semiconductor research and engineering talent, the lack of a professional IC design environment threatened to drive that talent abroad. This challenge became the principal motivation for the creation of entrepreneurial ventures capable of anchoring semiconductor careers within Portugal.

6

The Academic System: Excellence Without Translation

Portugal repeatedly demonstrated the ability to generate knowledge, infrastructure, and talent in semiconductor-related fields.

“

The system has not been designed to convert knowledge into sustained industrial capability.

Portugal’s challenge was never talent. It was translation.

The establishment of internationally funded research infrastructures marked the culmination of decades of investment in education, research, and technology development, providing Portugal with scientific capabilities comparable to those of much larger innovation ecosystems. Translating these assets into a broader and more sustainable industrial ecosystem, however, remained an enduring challenge.

6.1 A Strong but Under-Leveraged Asset

Over several decades, Portugal has developed a credible and internationally recognised academic base in fields directly relevant to semiconductors.

These include:

- microelectronics
- analog and mixed-signal design
- telecommunications and signal processing
- embedded and cyber-physical systems
- among others

Portugal’s trajectory

Universities and research centres have consistently produced:

- highly trained engineers and PhDs
- peer-reviewed scientific output
- participation in international research networks and consortia

In multiple cases, Portuguese researchers have achieved:

- leadership roles in European R&D projects
- visibility in leading conferences and journals
- sustained collaboration with global academic institutions

This establishes a key premise that Portugal has not lacked scientific capability in semiconductor-related domains.

In successful semiconductor ecosystems, academia performs two essential and interconnected roles:

01 Knowledge creation

- advancing the scientific and technological frontier
- generating new architectures, processes, and methodologies

02 Capability and value transmission

- training engineers and researchers
- transferring knowledge into industrial environments
- enabling startup formation and innovation pipelines

The second function is decisive.

In leading ecosystems, such as those in the United States, Israel, or Taiwan, academic institutions are not isolated knowledge producers. They are **embedded in industrial systems**, actively contributing to economic value creation.

6.2 The Portuguese Gap: From Knowledge to Impact

In Portugal, the first function, knowledge creation, has been consistently achieved. The second, **systematic translation into industrial and economic impact**, has been significantly weaker.

This gap manifests in several observable ways:

01 Limited commercialisation of research

low conversion of academic outputs into products, IP, or companies

02 Weak deep-tech startup formation

relatively few semiconductor ventures originating directly from academic research

03 Fragmented industry collaboration

interactions exist, but are often:

- project-based
- short-term
- not structurally embedded

04 Lack of scaling pathways

absence of clear progression from:

- laboratory research → prototype → product → company

This leads to a systemic condition that knowledge is generated, but not consistently converted into sustained economic value.

6.3 Structural Causes of the Translation Gap

This gap reflects structural characteristics of the system, rather than individual shortcomings.

1. Incentive structures

Academic careers are primarily driven by:

- publications
- citations
- teaching metrics

Industrial outcomes, such as patents, startups, or technology transfer, play a secondary role.

2. Institutional separation

Universities and industry operate under different:

- time horizons
- performance metrics
- risk tolerances

Without dedicated bridging mechanisms, alignment remains limited.

3. Limited access to patient capital Deep-tech semiconductor ventures require:

- long development cycles
- specialised expertise
- sustained financial support

Historically, such capital has been limited in Portugal.

4. Absence of strong intermediary institutions

Successful ecosystems typically rely on organisations that:

- connect research with industry
- de-risk early-stage technologies
- enable scaling

These mechanisms have been underdeveloped in the Portuguese context.

6.4 Historical Precedent

Long before the creation of large-scale nanotechnology research infrastructures in Portugal, the country had already undertaken ambitious efforts to establish advanced microelectronics and semiconductor-related capability through organizations such as INESC and UNINOVA.

These institutions represented some of the earliest serious attempts to create domestic competence in semiconductor process technologies, microfabrication, and microsystems engineering.

Unlike purely academic laboratories, these initiatives combined:

- research activity,
- engineering development,
- and industrial ambition.

The original vision included the creation of fabrication-oriented infrastructure capable of supporting commercial semiconductor and microsystems activities within Portugal.

At the time, this strategy reflected a broader international perception that meaningful participation in the semiconductor industry required some degree of manufacturing capability and process know-how.

Important technological capabilities were in fact established:

- clean-room infrastructure,
- advanced process expertise,
- microfabrication competence,
- and highly specialized engineering talent.

However, the structural economics of semiconductor manufacturing evolved rapidly and aggressively.

Competitive semiconductor fabrication increasingly depended on:

- extremely high capital expenditure,
- continuous technology reinvestment,
- large-scale production volumes,
- and deep integration into global industrial supply chains.

Portugal's trajectory

Although INESC, UNINOVA, and later also other research institutions succeeded in developing important technological competence and high-quality human capital, the level of investment required to transform their clean-room facilities into globally competitive industrial infrastructure was never realistically attainable within the Portuguese context.

As a consequence, these institutions evolved primarily into:

- research and prototyping environments,
- talent formation centers,
- and scientific capability platforms,

rather than sustainable industrial manufacturing anchors. This distinction is critical.

The issue was not the absence of technical competence, scientific quality, or ambition.

Rather, the surrounding economic and industrial system lacked the scale, capital intensity, and market integration necessary to sustain internationally competitive semiconductor manufacturing activities.

As a result, many highly trained researchers and engineers produced within these environments eventually migrated toward:

- foreign semiconductor ecosystems,
- multinational companies,
- or other sectors capable of absorbing advanced technical talent.

This historical trajectory strongly reinforces one of the central arguments of this document:

Portugal repeatedly demonstrated the ability to generate knowledge, infrastructure, and talent in semiconductor-related fields, but struggled to create the structural conditions necessary to retain and scale them into durable industrial capability.

6.5 Large-Scale Investment Without Systemic Impact

A more recent and particularly illustrative example of the translation gap at scale is the International Iberian Nanotechnology Laboratory (INL).

INL represents one of the most significant public investments in advanced nanotechnology and micro/nanoelectronics-related infrastructure in the Iberian Peninsula, with total investment on the order of **hundreds of millions of euros**.

Portugal's trajectory

The institution was designed to:

- conduct cutting-edge research
- attract international scientific talent
- act as a bridge between science and industry
- contribute to economic and technological development

In conceptual terms, this aligns with models observed in successful ecosystems, where research centres act as **anchors for innovation and industrial collaboration**.

6.6 Observed Outcomes and Structural Limitations

Despite this ambition and investment scale, the observable impact of INL on Portugal's semiconductor and microelectronics industrial landscape has been limited.

Three dimensions are particularly relevant:

01 Limited industrial anchoring

- relatively weak presence of major semiconductor industry partnerships centred in Portugal
- limited role as a core node within European semiconductor industrial networks

02 Modest entrepreneurial output

- limited generation of deep-tech startups directly emerging from its activities
- absence of a strong pipeline of scalable ventures

03 Constrained ecosystem integration

- the institution operates largely as a standalone research entity
- limited integration into a broader national semiconductor ecosystem

This leads to the critical observation that the scale of investment in research infrastructure has not translated proportionally into industrial impact.

6.7 Structural Interpretation

The INL case should not be interpreted as a failure of scientific ambition or capability. On the contrary, it reflects:

- the ability to mobilize significant public investment
- a clear intention to participate in advanced technological domains
- the presence of high-level research activity

The limitation lies in the absence of effective translation mechanisms.

The missing element is not research, it is the system that connects research to industry, capital, and markets.

Without:

- strong industrial co-development
- embedded commercialisation pathways
- entrepreneurial ecosystems
- sustained engagement with global semiconductor players

Even well-funded institutions risk operating in relative isolation.

6.8 Contrast with Effective Translation Models

The contrast with institutions such as IMEC is instructive.

While both operate at high levels of scientific excellence, the differentiating factors include:

- deep, long-term partnerships with global semiconductor companies
- shared technology platforms accessible to industry
- co-development models aligned with industrial roadmaps
- structured pathways from research to commercialisation

The distinction is not scientific, it is **organisational and strategic**.

6.9 The Chipidea Exception

Within this broader context, the emergence of Chipidea, Acacia, SiliconGate (5) represents a notable exception. The 3 startups effectively performed functions that were not systematically present in the ecosystem:

- translation of advanced knowledge into industrial IP
- training of engineers in a production environment
- direct engagement with global markets
- creation of entrepreneurial pathways

In doing so, it acted as a de facto bridge between academia and industry.

This reinforces the key insight that the success of Chipidea was not only technological, it was systemic, addressing the translation gap directly.

6.10 Consequences of the Translation Gap

The absence of systematic translation mechanisms has long-term implications:

1. Underutilisation of talent

Highly trained individuals: →

- migrate to other sectors
- or leave the country

2. Limited industrial depth

Scientific output does not accumulate into: →

- companies
- products
- scalable economic activity

3. Fragmented ecosystems

- weak feedback loops
- lack of critical mass
- limited cross-institutional integration

4. Dependence on external actors

Industrial activity remains dependent on:

- multinational decisions
- external strategic priorities

6.11 Reframing the Issue

It is important to frame the issue correctly.

The problem is not:

- lack of talent
- lack of intelligence
- lack of ambition

The problem is structural:

the system has not been designed to convert knowledge into sustained industrial capability.

6.12 Lessons for Strategy

This analysis leads to several key conclusions:

01 Research excellence is necessary but insufficient

Without translation mechanisms, it does not generate industrial impact.

02 Bridging institutions are critical

Entities connecting academia and industry must be:

- deliberate
- well-funded
- strategically integrated

03 Incentives must evolve

Academic systems should:

- value industrial impact alongside scientific output

04 End-to-end pathways must be created

Clear trajectories are required from:

research → development → commercialisation → scaling

6.13 The Fourth Structural Pattern

This establishes a fourth recurring pattern in Portugal's semiconductor trajectory:

- strong academic capability
- high-quality talent formation

But:

→ weak industrial translation

→ limited commercialisation

→ fragmented impact

This pattern can be summarised as excellence without translation

6.14 Transition to Structural Diagnosis

At this stage, four structural patterns have been identified:

1. **Entry without anchoring**
2. **Capability without control**
3. **Control with scalability**
4. **Excellence without translation**

The next step is to integrate these into a **system-level diagnosis**:

- **Why do these patterns recur?**
- **What structural gaps explain them?**
- **How do they interact?**

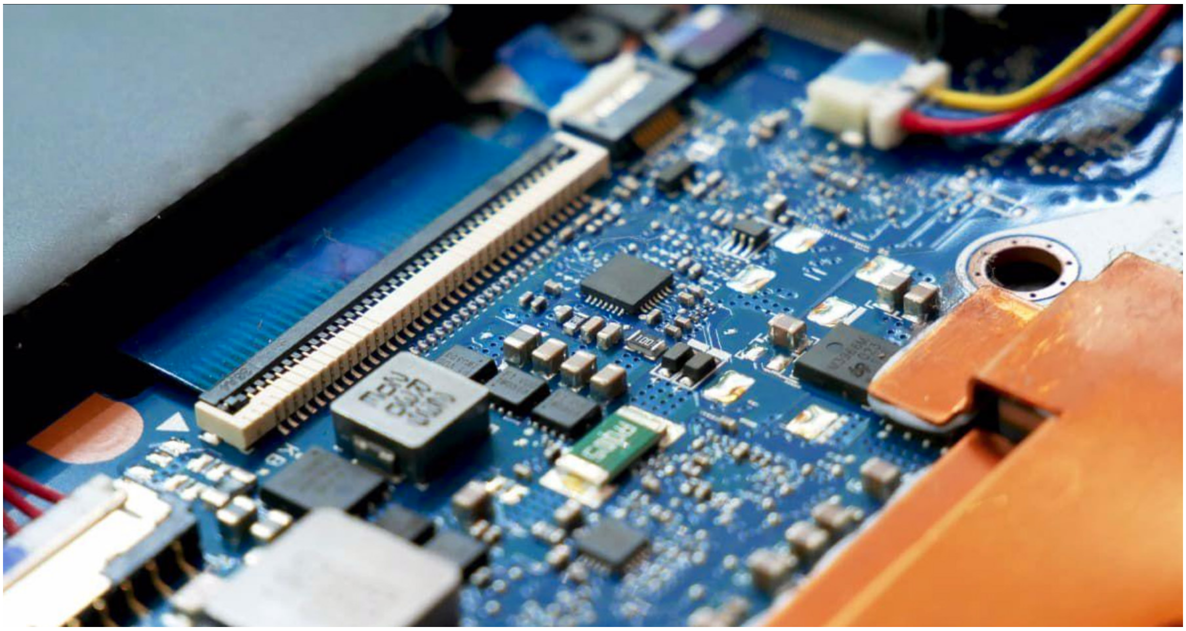
These questions will be addressed next.

Portugal's trajectory

Over several decades, the academic system successfully built human capital in microelectronics and related disciplines. Transforming this educational strength into sustained industrial scale would prove a more complex challenge.

Over several decades, Portugal invested in advanced research laboratories, cleanroom facilities, and microfabrication infrastructure, creating the scientific and technological capabilities required for research and innovation in microelectronics and nanotechnology.

Portugal’s trajectory



Portugal’s semiconductor journey demonstrates that educational excellence, research capability, and scientific infrastructure, while necessary, are not sufficient conditions for industrial success. The enduring challenge remains the effective translation of these strengths into a robust and sustainable technology ecosystem.

7

Patterns Across 40 Years

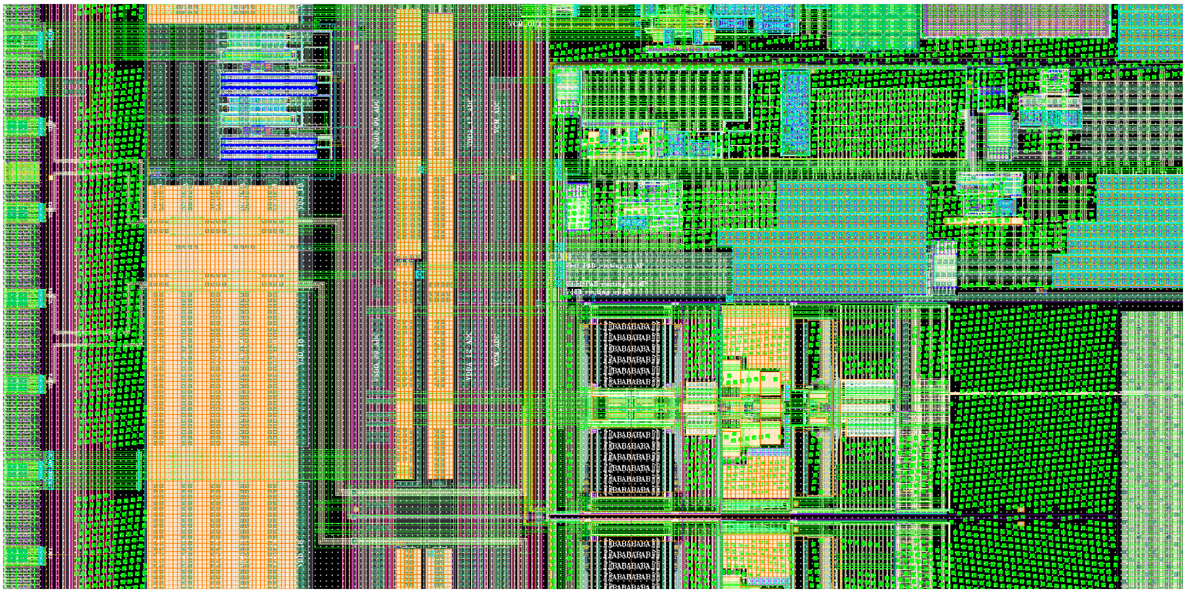
Across four decades, Portugal demonstrated its ability to educate engineers, build research institutions, attract industrial investments, and create successful design activities.

“

Participation alone does not create strategic advantage. Positioning does.

Portugal has repeatedly achieved presence, but not always positioning.

Structural diagnosis



A recurring lesson emerged over four decades: the strongest and most durable successes occurred where Portugal competed through talent, knowledge, and design expertise rather than through capital-intensive manufacturing activities.

7.1 From Episodes to Structure

Previously, the document examined distinct phases of Portugal's participation in the semiconductor industry:

- multinational-led industrial entry
- industrial upgrading under external control
- emergence of a design-led success case
- development of a strong academic base with limited industrial translation

Individually, these episodes provide valuable insights. Taken together, they reveal something more important: a set of recurring structural patterns that have shaped outcomes over four decades.

The purpose here is to move from **description to diagnosis:**

- not what happened,
- but why similar outcomes emerged repeatedly

7.2 The Four Structural Patterns

The analysis so far has identified four consistent patterns.

01

Entry without anchoring (3)

- attraction of multinational activity
- positioning in lower-value segments
- absence of long-term embedding

02

Capability without control (4)

- industrial upgrading
- increased technological sophistication
- but external ownership and decision-making

03

Control with scalability (5)

- entry into high-value design/IP segments
- local capability formation
- global validation and ecosystem emergence

04

Excellence without translation (6)

- strong academic output
- high-quality talent formation
- weak conversion into industrial activity

These patterns are not isolated, they are interconnected expressions of the same underlying system.

7.3 A First Synthesis: Presence vs Positioning

A key distinction emerges across all phases: Portugal has repeatedly achieved presence, but not always positioning

- Presence refers to participation in the industry
- Positioning refers to control over value, direction, and long-term outcomes

Across the first two phases:

- presence was achieved
- positioning was weak

In the third phase (Chipidea):

- positioning began to emerge

In the academic system:

- capability exists, but positioning in the value chain remains indirect

This distinction is central:

Participation alone does not create strategic advantage. Positioning does.

7.4 The Role of the Value Chain

The semiconductor value chain provides a unifying lens.

Across the historical trajectory:

- early entry occurred in **low-value, mobile segments**
- later upgrading moved into more sophisticated industrial activities
- the most successful case (Chipidea) operated in **high-value, knowledge-intensive layers**

Structural diagnosis

This leads to a clear conclusion:

Outcomes are strongly determined by position in the value chain

- lower-value segments ⟶ mobility, instability
- mid-level industrial segments ⟶ capability, but vulnerability
- high-value design/IP ⟶ scalability, defensability and anchoring

7.5 Control as a Determining Variable

A second cross-cutting factor is **control**.

Across the phases:

- multinational-led operations ⟶ **external control**
- upgraded industrial activities ⟶ **external control persists**
- Chipidea ⟶ initial local control, later integrated but anchored

Control determines:

- investment decisions
- upgrading trajectories
- survival during downturns
- capacity to capture value

This leads to the central principle that capability without control limits strategic outcomes

7.6 The Missing Middle: Translation Mechanisms

The academic system introduces a third structural dimension: **translation**.

Portugal demonstrates:

- strong knowledge creation
- strong talent formation

But lacks:

- systematic conversion into companies, products, and industrial platforms

The absence of translation mechanisms explains why:

- academic excellence does not scale into industry
- industrial presence does not connect to research
- ecosystems remain fragmented

The INL case reinforces this at scale:

- significant investment
- high scientific ambition
- but limited industrial integration

This leads to the systemic insight that the bottleneck is not knowledge, it is conversion

7.7 Talent as the Hidden Variable

Across all phases, one variable appears repeatedly: **talent**.

- early industrial phases ⟶ limited depth of engineering talent
- academic system ⟶ strong talent formation
- Chipidea ⟶ talent creation, retention, and multiplication

Structural diagnosis

The most successful phase (design/IP) is also the one where:

- talent is central
- knowledge is cumulative
- mobility generates ecosystem growth

This leads to the critical observation that talent is the only asset that compounds across phases, if it is retained and leveraged.

7.8 Fragmentation vs System Design

A broader pattern becomes visible: Portugal has accumulated components of a semiconductor ecosystem, but not a fully integrated system.

These components include:

- industrial experience
- academic capability
- entrepreneurial success cases
- multinational presence

However, they have remained:

- partially disconnected
- weakly coordinated
- lacking a unifying strategic framework

This fragmentation explains why:

- successes did not scale
- capabilities did not reinforce each other
- opportunities were not fully leveraged

7.9 The Core Structural Gap

Synthesising the previous sections, the core structural gap can be defined as the absence of a coordinated system linking talent, research, industry, capital, and strategy.

More specifically, Portugal has lacked:

- clear positioning within the value chain
- mechanisms for upgrading industrial activity
- translation pathways from academia to industry
- scaling mechanisms for entrepreneurial initiatives
- long-term strategic continuity

This is not a resource problem. It is a **system design problem**.

7.10 What Worked, and Why

Despite these gaps, the analysis also reveals what did work.

The Chipidea case succeeded because it combined:

- positioning in a high-value segment (design/IP)
- local capability and control
- strong integration into global markets
- creation of talent and entrepreneurial spillovers

In other words, it aligned:

- value chain position
- control
- talent
- global integration

This alignment is what the broader system has lacked.

7.11 A Diagnostic Framework

The Portuguese semiconductor trajectory can now be summarised through four key dimensions:

Dimension	Weak Phases	Strong Phase (Chipidea)
Value chain position	Low / mid	High (design/IP)
Control	External	Initially local, then anchored
Translation	Weak	Strong (company-driven)
Talent dynamics	Limited / fragmented	Accumulative and generative

This framework provides a structured way to evaluate future initiatives.

7.12 Implications for the Next Phase

The patterns identified over the past 40 years lead to the clear conclusion that future success will depend on deliberately correcting structural gaps, not repeating historical approaches.

Specifically:

- attraction must be combined with **anchoring mechanisms**
- upgrading must be combined with **control and influence**
- research must be connected to **industrial pathways**
- talent must be retained and amplified
- initiatives must be coordinated within a coherent system

7.13 Transition to International Benchmarking

With a clear diagnostic framework established, the next step is to examine how other countries have successfully addressed similar challenges.

The objective is not to replicate external models, but to:

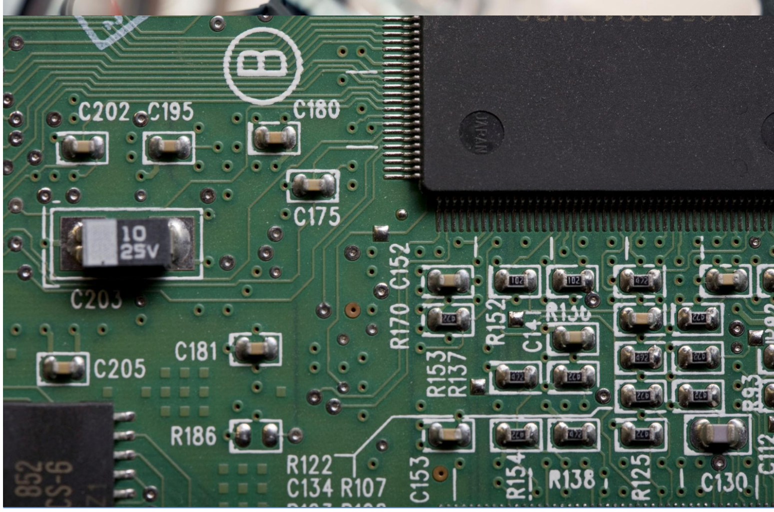
- identify transferable mechanisms
- distinguish between context-specific and universal elements
- refine a realistic strategy for Portugal

This will be the focus next.

Structural diagnosis

A recurring pattern emerged throughout Portugal's semiconductor history: the successful attraction of industrial activities was not always accompanied by the creation of durable local capabilities, technology ownership, or ecosystem anchoring.

One of the most consistent strengths of the Portuguese semiconductor ecosystem has been its ability to produce highly skilled engineers. One of its most enduring weaknesses has been the limited availability of industrial opportunities capable of absorbing and retaining them at scale.



Across four decades, Portugal demonstrated its ability to educate engineers, build research institutions, attract industrial investments, and create successful design activities. The remaining challenge is to connect these strengths into a coherent and self-reinforcing innovation ecosystem capable of generating sustained technological and economic impact.

8

Learning from Global Success Models

Successful semiconductor ecosystems are not the result of isolated initiatives, they are the outcome of coherent, long-term system design.

“

Portugal should not attempt to replicate a single model, it should combine compatible elements.

The synthesis points toward a hybrid strategy.

8.1 From Diagnosis to Benchmarking

Previously, in 7, the document established that Portugal's semiconductor trajectory has been shaped by four structural gaps:

- weak anchoring of industrial activity
- limited control over strategic assets
- insufficient translation from research to industry
- fragmentation of ecosystem components

The purpose now is to examine how other countries have addressed similar challenges successfully.

The focus is not on replicating models, but on extracting **transferable mechanisms**.

Successful semiconductor ecosystems are not the result of isolated initiatives, they are the outcome of coherent, long-term system design.

8.2 Three Archetypes of Success

Global experience suggests that successful semiconductor strategies tend to cluster around three archetypes:

1. **Scale and manufacturing dominance**
2. **Design and innovation ecosystems**
3. **FDI-driven industrial anchoring**

A fourth, complementary model is particularly relevant:

4. **Research-to-industry translation platforms**

Each of these addresses a different structural challenge.

8.3 Taiwan — Scale, Focus, and Strategic Continuity

Anchor entities

- TSMC
- Industrial Technology Research Institute

Core mechanism

Taiwan's strategy was based on:

- clear focus on a specific value chain segment (foundry)
- long-term state commitment
- creation of institutional bridges (ITRI)
- scaling through global customer integration

The creation of TSMC was not accidental, it was a deliberate strategic act, supported by policy, talent, and sustained investment.

Key outcomes

- global leadership in advanced semiconductor manufacturing
- deep ecosystem integration
- long-term technological accumulation

Key lesson

Focus + scale + continuity over decades

= global leadership

Relevance to Portugal

- Direct replication is not feasible (capital intensity, scale constraints)
- However, transferable elements include:
  - → long-term policy consistency
  - → institutional coordination
  - → clear value chain positioning

8.4 Israel — Talent, Venture Capital, and Design Leadership

Anchor entities

- Yozma Program
- strong presence of multinational design centres

Core mechanism

Israel built a semiconductor ecosystem through:

- high-quality engineering talent
- venture capital catalysed by public policy
- tight integration with global companies
- strong entrepreneurial culture

The system connects:

- military R&D
- academia
- startups
- multinational corporations

Key outcomes

- dense startup ecosystem
- strong presence in semiconductor design
- global integration across multiple layers

Key lesson

Talent + capital + global integration

= sustained innovation

International benchmarking

Relevance to Portugal → **High.**

Portugal already possesses:

→ strong engineering base

→ emerging design capability (5)

Missing elements include:

→ scale-up capital

→ systematic startup pipelines

→ tighter ecosystem integration

8.5 Ireland — FDI Anchoring and Industrial Continuity

Anchor entities

- Intel
- IDA Ireland

Core mechanism

Ireland's approach focused on:

- systematic attraction of multinationals
- long-term relationship management
- alignment of incentives and capabilities
- progressive upgrading of activities

Crucially, Ireland did not treat FDI as transactional:

- it treated it as strategic and cumulative

International benchmarking

Key outcomes

- decades-long presence of major semiconductor players
- increasing technological sophistication
- integration into global production systems

Key lesson

Attracting is easy. → Anchoring is strategy.

Relevance to Portugal → **Moderate to high**

Portugal has demonstrated ability to attract companies (3), but:

→ lacked long-term anchoring mechanisms

→ lacked systematic upgrading frameworks

8.6 Belgium — Research-to-Industry Translation (IMEC Model)

Anchor entities

- IMEC

Core mechanism

IMEC represents a distinct model:

- world-class research
- deep industrial co-development
- shared technology platforms
- global partnerships with leading semiconductor firms

Unlike traditional academic institutions, IMEC operates as a platform where research and industry are structurally integrated.

International benchmarking

Key outcomes	• global leadership in nanoelectronics research • strong industrial relevance • continuous translation into applications and partnerships
Key lesson	Research creates value only when embedded in industrial systems

Relevance to Portugal → **Very high.**

This model directly addresses the gap identified in 6:

→ strong academic base

→ weak translation mechanisms

The contrast with INL is particularly instructive:

→ similar ambition

→ different system design

8.7 Comparative Synthesis

These four models can be summarised as follows:

Model	Core Mechanism	Strength	Portugal Fit
Taiwan	Scale & manufacturing	Global dominance	Low
Israel	Design & startups	Innovation density	High
Ireland	FDI anchoring	Industrial continuity	High
Belgium (imec)	Research translation	Industry integration	High

8.8 What Is Transferable, and What Is Not

A critical distinction must be made between:

Non-transferable elements

- scale of capital investment (Taiwan)
- historical timing advantages
- unique geopolitical conditions

Transferable mechanisms

- clear strategic positioning
- institutional coordination
- long-term policy continuity
- integration of talent, research, and industry
- creation of scaling pathways

The benchmarking analysis leads to the precise conclusion that Portugal should not attempt to replicate a single model, it should combine compatible elements.

Specifically:

From Israel

- design-led ecosystem
- startup generation
- global integration

From Ireland

- structured multinational anchoring
- long-term industrial relationships

From IMEC

- effective research-to-industry translation

Avoid → attempting Taiwan-style manufacturing scale

8.9 Toward a Hybrid Model

The synthesis points toward a **hybrid strategy**:

- **Design hub** (talent + IP + startups)
- **Anchored multinationals** (long-term industrial presence)
- Translation platforms (research → industry)

This aligns closely with:

- Portugal's demonstrated strengths
- Europe's structural needs

8.10 Transition to Strategy

Next, the document will translate these insights into a **concrete strategic framework:**

- What should Portugal do differently?
- What should be prioritised?
- How should efforts be coordinated?

This is the final step: from learning to action

9

Europe's Semiconductor Ambition and the Talent Gap

Europe is investing heavily in semiconductors, but talent has become the binding constraint. Portugal's opportunity lies in helping fill that gap through design capability and engineering talent.

“

Portugal can supply and scale the design talent that Europe lacks.

Europe’s challenge is no longer capital. It is talent.

The evolution of Portugal's semiconductor ecosystem demonstrates that long-term investment in education, research, and entrepreneurial activity can create internationally competitive design capabilities. As Europe confronts a growing shortage of semiconductor talent, Portugal's established IC design community represents a strategic asset, contributing specialised expertise to a more resilient and technologically sovereign European ecosystem.

9.1 Europe's Strategic Repositioning

Over the past decade, and particularly following the supply chain disruptions of the COVID-19 period, semiconductors have moved to the center of Europe's industrial and geopolitical agenda. The European Union has recognised that:

- dependence on external semiconductor supply chains represents a **strategic vulnerability**
- advanced technologies such as artificial intelligence, mobility, and defense require **secure and competitive semiconductor capabilities**

Strategy and action

In response, the EU has launched a coordinated policy framework centred on the European Chips Act. This initiative aims to:

- increase Europe's share of global semiconductor production
- strengthen technological sovereignty
- mobilize tens of billions of euros in public and private investment
- support the full value chain, from research to manufacturing

This represents a structural shift: Semiconductors are no longer treated as a sector, they are treated as strategic infrastructure.

9.2 Europe's Structural Imbalance

Despite strong industrial and scientific assets, Europe's semiconductor ecosystem remains **structurally unbalanced**.

Strengths

- global leadership in key equipment segments
- strong industrial demand (automotive, industrial systems)
- high-quality research institutions

Weaknesses

- limited scale in advanced logic manufacturing
- fragmented design ecosystem
- insufficient density of semiconductor startups
- lack of critical mass in experienced design talent

This imbalance creates a critical bottleneck.

Europe is investing heavily in:

- fabrication capacity
- research infrastructure

But it lacks sufficient human capital in key technical domains to fully leverage these investments

9.3 The Talent Bottleneck

Across the semiconductor value chain, talent is a central constraint, but it is particularly acute in **design and system-level engineering**.

Europe faces shortages in:

- analog and mixed-signal designers
- digital system architects
- verification engineers
- process integration specialists
- advanced packaging experts

These roles require:

- years of specialised training
- hands-on experience in complex projects
- exposure to global best practices
- They cannot be scaled rapidly.

At the same time:

- global competition for talent is intense
- the United States and Asia maintain strong pull factors
- European education systems are not producing sufficient numbers at scale

The result is clear: capital is increasingly available, talent is the binding constraint

9.4 Why Talent Matters More Than Capacity

A common policy focus is on manufacturing capacity, particularly the construction of semiconductor fabs. However, capacity without talent creates limited value.

Semiconductor systems require:

- design input to define architectures
- engineers to optimize performance
- integration across hardware and software layers

Even manufacturing itself depends on:

- highly specialised engineers
- continuous process optimisation
- deep technical expertise

Without sufficient talent:

- fabs operate below potential
- innovation cycles slow
- value capture shifts to regions with stronger design ecosystems

This leads to a fundamental conclusion: Semiconductors are ultimately a talent-driven industry, even in their most capital-intensive segments.

9.5 Portugal's Strategic Opportunity

Within this European context, Portugal occupies a position that is both **modest in scale and significant in potential**.

Strategy and action

The country does not have:

→ large-scale fabrication capacity
→ dominant industrial players

But it does have:

→ a growing base of semiconductor design engineers (5)
→ a proven model of design-led success (Chipidea)
→ a solid academic pipeline (6)
→ integration into global design networks

This leads to the precise opportunity that Portugal can position itself as a European hub for semiconductor design talent.

This is not a generic ambition. It is grounded in:

→ existing capability
→ demonstrated trajectory
→ alignment with European needs

9.6 From National Capability to European Role

Portugal's semiconductor strategy should therefore be framed not in isolation, but as a **contribution to Europe's overall system**.

This requires a shift in perspective:

from → "what industry can Portugal build domestically?"
to → "what critical function can Portugal perform within Europe?"

The answer, based on the analysis, is:

Portugal can supply and scale the design talent that Europe lacks

"

Portugal can supply and scale

the design talent that Europe lacks

"

9.7 A Talent-Centric Strategy

To operationalise this role, Portugal must adopt a **talent-centric semiconductor strategy**, structured around three pillars.

01 Scaling Talent Formation

- expand specialised education in IC design
- strengthen links between universities and industry
- create intensive training programs aligned with real-world needs

→ The objective is not incremental growth, but **order-of-magnitude scaling**.

02 Deepening the Design Ecosystem

- support semiconductor startups
- attract additional multinational design centers
- reinforce existing hubs (e.g., around Synopsys)

→ The objective is to **create a dense, interconnected design ecosystem.**

03 Integrating with European Industry

- align with EU semiconductor initiatives
- partner with major European and global companies
- position Portugal as a preferred location for design activities

→ The objective is **system-level integration, not isolated growth**.

9.8 Differentiation Within Europe

A critical element of strategy is **differentiation**.

Portugal should not attempt to replicate:

- Germany's manufacturing strength
- France's large-scale industrial policy
- other countries' capital-intensive approaches

Instead, it should define **a clear role: Design talent at scale as a national specialisation**

This positioning is:

→ realistic
→ defensible
→ complementary to other European capabilities

9.9 A European Value Proposition

Based on this positioning, Portugal can articulate a clear value proposition:

- Talent hub for semiconductor design
- Platform for multinational design centres
- Incubator for deep-tech semiconductor startups

This aligns with:

- Europe's structural needs
- Portugal's demonstrated strengths
- the lessons derived from previous discussions

9.10 From Opportunity to Execution

The existence of this opportunity does not guarantee its realisation.

Execution requires:

- strategic clarity
- institutional coordination
- sustained commitment

The risk is not lack of potential, it is **lack of alignment and scale**.

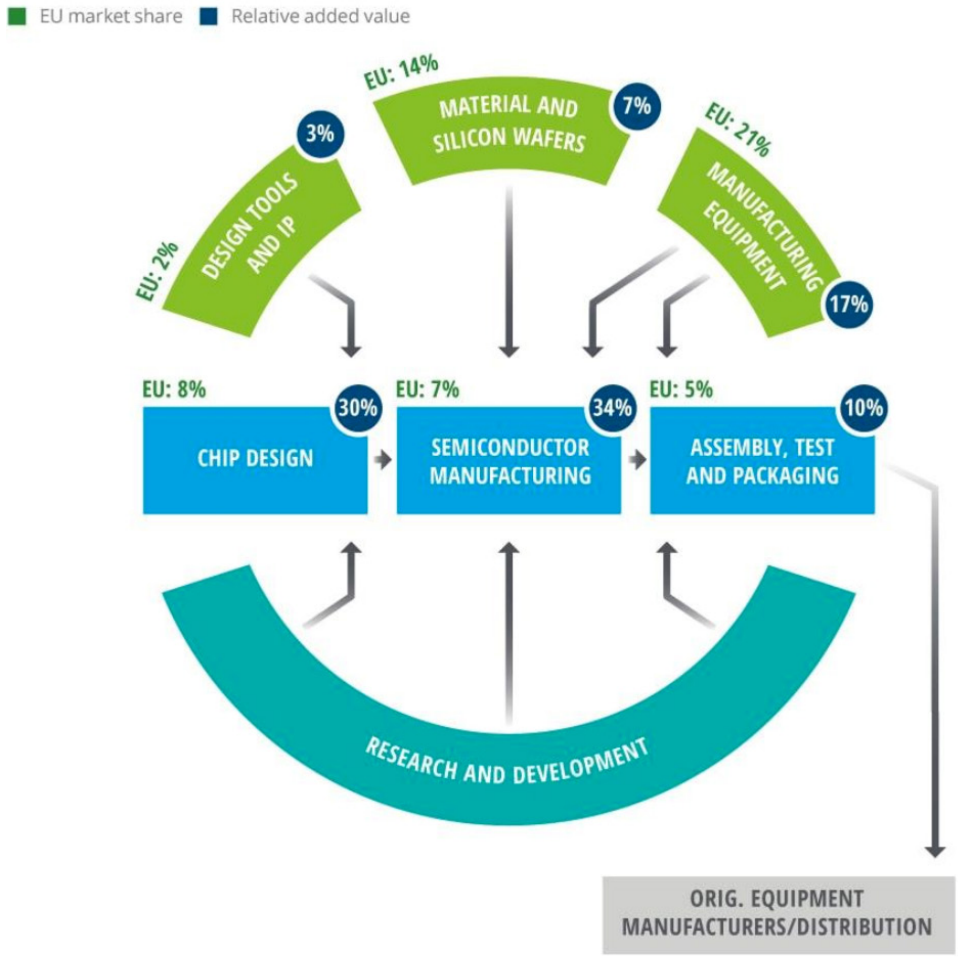
9.11 Transition to National Strategy

Here, the document establishes Portugal's potential role within Europe.

The final step is to define what Portugal must do, concretely and systematically, to realize this role. This is the focus next.

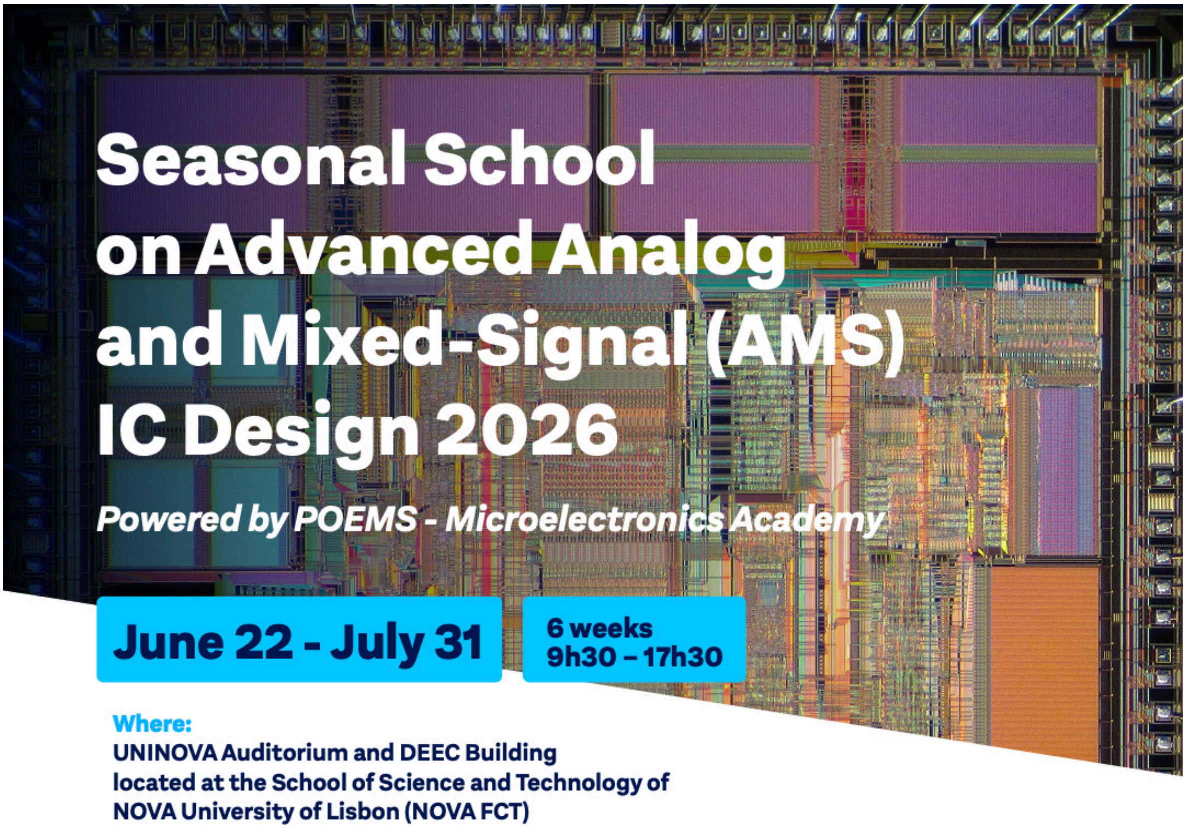
Strategy and action

The main segments of the semiconductor supply chain with relative added value and EU market share



The semiconductor value chain highlights the strategic importance of chip design as one of the industry's highest value-added activities.

Europe's ambition to strengthen technological sovereignty will depend not only on investments in manufacturing capacity but also on expanding its design and innovation capabilities. For countries such as Portugal, this creates a unique opportunity to contribute through talent development, advanced engineering education, and specialised design expertise, reinforcing Europe's semiconductor ecosystem while addressing its growing skills gap.



Seasonal School on AMS IC Design (2026). Advanced training initiatives illustrate how Portugal can contribute to Europe's semiconductor ambitions by expanding specialised design talent and strengthening industry-academia links.

10

What Should Portugal Do Now

Portugal's greatest opportunity in semiconductors lies in becoming a leading European hub for integrated circuit design talent.

“

Portugal does not need to invent a new path. It needs to scale and systematise the path it has already proven can work.

The challenge is execution at scale.

10.1 From Diagnosis to Action

The preceding discussions lead to a clear conclusion:

- Portugal has participated in the semiconductor industry for over four decades
- it has accumulated capabilities, talent, and experience
- but it has not consistently translated these into durable strategic positioning

At the same time:

- Europe is investing heavily in semiconductors
- a structural talent gap has emerged
- a window of opportunity is open

The question is no longer whether Portugal should participate.

The question is how Portugal can participate in a way that is focused, scalable, and strategically relevant.

10.2 A Strategic Principle: Focus Over Breadth

Portugal cannot build a full-spectrum semiconductor industry.

Any attempt to:

- replicate manufacturing-heavy models
- cover all layers of the value chain
- pursue symbolic technological sovereignty

would lead to fragmentation and inefficiency.

The strategic principle must be explicit:

Portugal should focus on a small number of high-impact positions where it can build sustained advantage.

10.3 The Hybrid Model for Portugal

Based on the analysis, a coherent strategy emerges:

A design-led ecosystem, anchored by multinationals, enabled by strong translation mechanisms

This model integrates:

- → Design and IP leadership (Chipidea model)
- → **FDI anchoring** (Ireland model)
- → Research-to-industry translation (IMEC model)
- → European integration and talent supply

10.4 Pillar 1 — Scale Semiconductor Design Talent

This is the central pillar.

Portugal must aim to become a European hub for semiconductor design talent at scale

Objectives

- expand from ~1000 engineers to a significantly larger base
- increase depth in:
  - → analog and mixed-signal
  - → digital system design
  - → verification and system integration

Key actions

- widen the sourcing base of talent
- expand specialized university programs
- create industry-aligned training tracks
- attract international talent
- support continuous professional development

Rationale

- talent is the primary constraint in Europe
- design is Portugal’s strongest proven domain

10.5 Pillar 2 — Build a Dense Design Ecosystem

Talent alone is insufficient ⟶ it must be embedded in an ecosystem.

Objectives	• increase the number of: ⟶ startups ⟶ design houses ⟶ multinational design centres
Key actions	• support semiconductor startups (early-stage funding, mentoring) • facilitate creation of spin-offs from existing companies • attract additional design activities from global firms • reinforce hubs around existing anchors
Rationale	• ecosystems generate: ⟶ talent mobility ⟶ knowledge diffusion ⟶ entrepreneurial activity

10.6 Pillar 3 — Anchor Multinational Presence

Portugal has demonstrated the ability to attract multinational companies. The challenge is to anchor and upgrade their presence.

Objectives	• ensure long-term commitment • increase technological depth of local operations

Strategy and action

Key actions

- develop long-term partnership frameworks
- align education and training with company needs
- create incentives linked to:
  - → capability development
  - → R&D activity
  - → ecosystem engagement

Rationale

- multinationals provide:
  - → scale
  - → global integration
  - → access to markets

10.7 Pillar 4 — Create Effective Translation Mechanisms

This addresses the core gap identified in 6.

Objectives

- convert research into:
  - → products
  - → companies
  - → industrial partnerships

Key actions

- redesign technology transfer mechanisms
- incentivise industrial collaboration
- support applied research aligned with market needs

Reference model

- Israel

Rationale

- research without translation does not create economic impact

10.8 Pillar 5 — Align with European Strategy

Portugal's strategy must be **embedded in Europe**.

Objectives	position Portugal as: → a talent supplier → a design hub → a partner in EU initiatives
Key actions	• actively participate in programs under the European Chips Act • align national initiatives with European priorities • build cross-border partnerships
Rationale	• scale and funding are increasingly European • national strategies must be compatible with EU frameworks

10.9 Institutional Coordination: The Critical Enabler

The success of this strategy depends on **coordination**.

Portugal must align:

→ government policy
→ universities and research institutions
→ industry
→ venture capital and financing

This requires:

- clear governance structures
- long-term commitment
- continuity across political cycles

Without coordination, even well-designed strategies fail in execution.

10.10 What to Avoid

Equally important is what Portugal **should not do**.

1. Avoid dispersion of effort

→ Too many initiatives dilute impact.

2. Avoid symbolic projects without structural impact

→ Large investments without ecosystem integration (as seen in 6) must be avoided.

3. Avoid short-termism

→ Semiconductor ecosystems require sustained commitment over decades.

4. Avoid misalignment with the value chain

→ Efforts must focus on areas of realistic competitive advantage.

10.11 Measuring Progress

A strategy must be measurable.

Key indicators include:

- number of IC design engineers
- number of semiconductor startups
- scale of multinational design operations
- volume of industry-academia collaboration
- integration into European programs

Progress should be tracked systematically to ensure execution discipline.

10.12 From Opportunity to Execution

Portugal’s position today is unique:

- it has demonstrated capability (Chipidea)
- it has latent potential (academic system)
- it has European alignment (Chips Act)

The challenge is not conceptual. The challenge is execution at scale.

10.13 Final Perspective

Over the past four decades, Portugal has experienced:

- entry without anchoring
- capability without control
- excellence without translation

It has also demonstrated:

- a successful, scalable model in design and IP

The next phase must be different.

It must be deliberate, focused, and sustained.
Portugal does not need to invent a new path.
It needs to scale and systematise the path it has already proven can work.

From Cycles to Strategy

The future of semiconductors in Portugal will not be determined by ambition alone, but by the ability to convert experience into strategy and strategy into sustained execution.

“

Portugal does not need to invent a new path.

It needs to scale and systematise the path it has already proven can work.

A Recurrent Pattern

Over four decades, Portugal's participation in the semiconductor industry has followed a recurring pattern:

- entry through multinational presence
- partial upgrading of capabilities
- emergence of isolated successes
- absence of sustained, system-level consolidation

This pattern can be summarised as presence without permanence.

The analysis conducted in this document has shown that this outcome is not accidental. It reflects structural characteristics:

- weak anchoring mechanisms
- limited control over strategic assets
- insufficient translation from research to industry
- fragmentation across institutions and initiatives

A Proven Alternative

At the same time, Portugal has demonstrated that a different trajectory is possible.

The emergence of a design-led ecosystem, originating from a single company and expanding into a broader network of talent, firms, and institutions, provides a **validated model**.

This model shows that:

- high-value participation is achievable
- talent can be developed and retained
- ecosystems can emerge through cumulative processes
- global integration can be leveraged effectively

Portugal does not lack capability ⟶ it lacks systematisation of that capability

A European Opportunity

The current European context introduces a new dimension. With the European Chips Act and related initiatives, Europe is:

- mobilising significant financial resources
- attempting to rebalance its position in the global semiconductor landscape
- confronting a structural shortage of specialised talent

This creates a window of opportunity.

But it also introduces a constraint: only countries with clear positioning and execution capacity will benefit meaningfully from this momentum.

A Strategic Choice

Portugal faces a strategic choice.

It can:

→ repeat past patterns

→ pursue fragmented initiatives

→ attempt to replicate models that are structurally misaligned

Or it can:

define a focused role, aligned with its capabilities and with Europe's needs.

The analysis developed in this document points to a clear direction:

→ design and IP as the core value layer

→ talent as the primary strategic asset

→ ecosystem formation as the mechanism of scale

→ European integration as the framework of action

From Potential to Execution

The path forward is conceptually clear.
The challenge is execution.

This requires:

- → sustained commitment over time
- → coordination across institutions
- → alignment between policy, academia, and industry
- → discipline in prioritisation

Without these elements, even well-designed strategies fail.
With them, small countries can achieve **disproportionate impact**.

A Final Perspective

Semiconductor ecosystems are not built through isolated decisions.
They are built through:

- accumulation
- iteration
- learning
- and alignment

Portugal's history provides both:

- **warnings** (what to avoid)
- **evidence** (what can work)

The next phase depends on whether this knowledge is used.

Closing Statement

"*The future of semiconductors in Portugal will not be determined by ambition alone,*

but by the ability to convert experience into strategy and strategy into sustained execution."

Abbreviations

AI	Artificial Intelligence
AMS	Analog and Mixed-Signal
EDA	Electronic Design Automation
EU	European Union
FDI	Foreign Direct Investment
IC	Integrated Circuit
IDA	Industrial Development Agency (IDA Ireland)
IMEC	Interuniversity Microelectronics Centre (Belgium)
INESC	Institute for Systems and Computer Engineering
INL	International Iberian Nanotechnology Laboratory
IP	Intellectual Property
ITRI	Industrial Technology Research Institute (Taiwan)
ITT	International Telephone and Telegraph Corporation
NOVA FCT	NOVA School of Science and Technology
RF	Radio Frequency
TISEP	Texas Instruments Samsung Electrónica Portugal
TSMC	Taiwan Semiconductor Manufacturing Company
UNINOVA	Institute for the Development of New Technologies

Semiconductors in Portugal presents a structured analysis of the country's four-decade trajectory in semiconductors, identifying recurring patterns, structural gaps, and a validated model for future growth.

Drawing on historical evidence, international benchmarking, and the evolving European policy landscape, the document argues that Portugal can establish a distinctive role as a design and talent hub within Europe's semiconductor ecosystem.

It offers a coherent framework that connects experience to structural lessons and translates those lessons into actionable strategy.

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