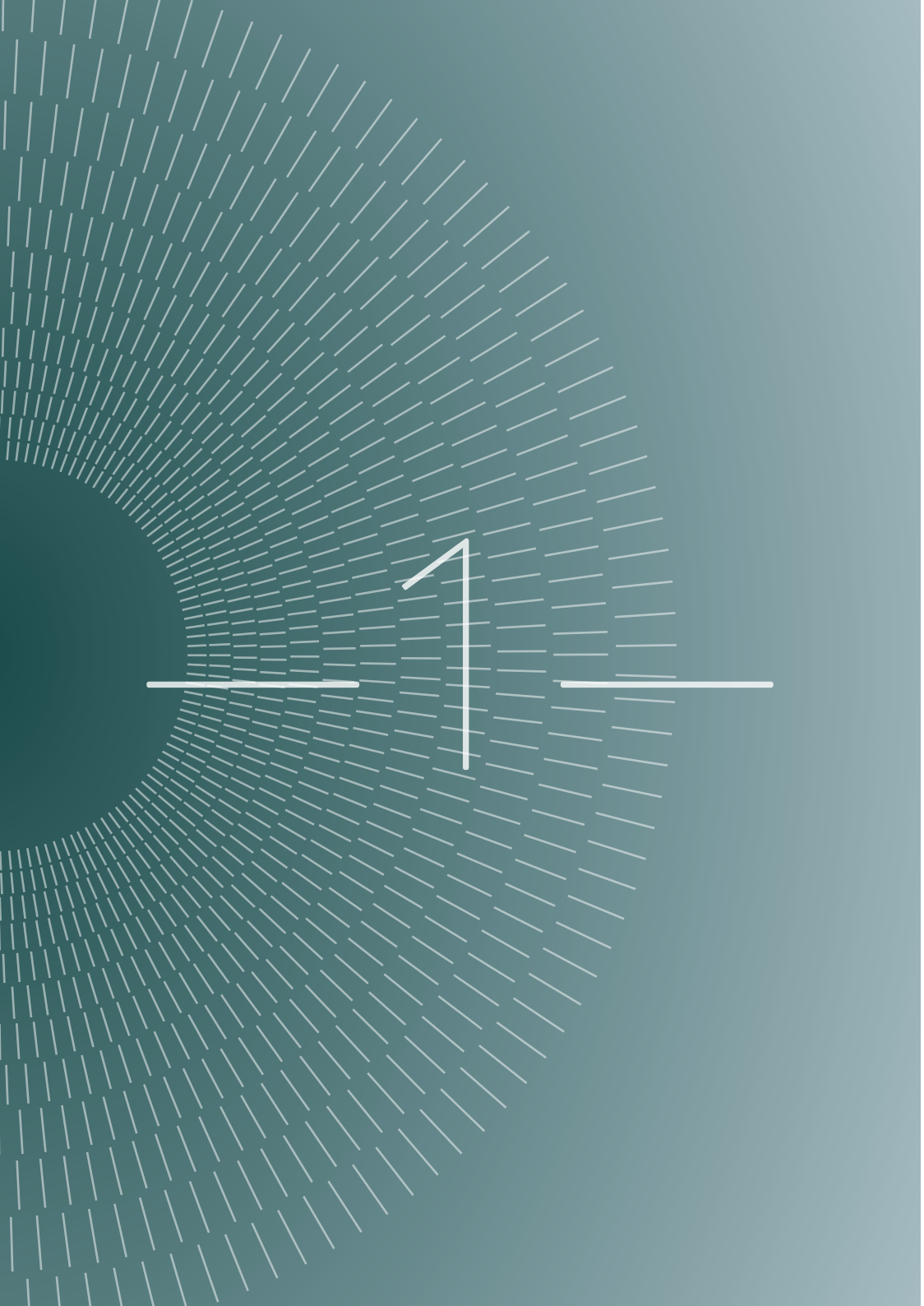
POLIMI 2040

THE NEW ROLE OF TECHNICAL AND SCIENTIFIC UNIVERSITIES IN THE ERA OF GLOBAL CHALLENGES

POLITECNICO
MILANO 1863

POLIMI 2040



AN EVOLVING GLOBAL LANDSCAPE

We are living through a period in history marked by momentous transformations which are compelling technical and scientific universities to take a hard look at their role in a society that is placing knowledge at the center of the processes of greater and more inclusive wellbeing.

Several of the current trends that should be highlighted in particular are:

→ The newly emerging geopolitical balances, with Asia accounting for more than 50% of the global economy and playing a controversial role within world balances through the particularly agile conditions linked to "market socialism" and its progressive access to technologies previously in the hands of western investors. These **new maps of knowledge and innovation**, with an increasing antagonism between the North American and Asian systems, emphasize a situation where some areas are becoming more attractive and others more recessive, guiding the growing flows of migration, which is now driven by the effects of climate crisis as well as by political and social instability. Against this backdrop, universities have shown that they can be a powerful prime mover for development in the creation and spreading of knowledge.

→ Ubiquitous digital technology, global connectivity, and the Fourth Industrial Revolution are producing a paradigmatic leap whose effects are still largely unexplored. Access to information and knowledge is apparently spreading, but there are distorting effects for both those who have access to technology and for those who do not. The **convergence of scientific and technological knowledge** is creating a hybridization between organic and inorganic sciences, where mechanical and information technology is hybridizing with life sciences and cognitive sciences, raising serious questions on the ethical front and prognosticating wide-reaching social impact. One of the greatest challenges for academic institutes is to rethink the boundaries of knowledge and plan for a more conscious exploration of the frontiers of innovation.

→ The gradual parting of ways between the financial system and the real economy and the ensuing crises at the start of this century have had heavy repercussions on western economies. The policies put in place to thwart these crises have ultimately precipitated recessive effects, joined by a reshaping of social policies and greater social inequality, with a general climate of weariness and mistrust in the institutional world. As a consequence, the upward progress of social and organizational sciences

slowed down in universities, with **increasing attention being paid to technical and scientific subjects**. This shift was supported by the breakneck development of new high-tech sectors, spewing out "unicorns" in the digital industry able to inject massive investment and stoke up training and research in the technical and scientific sectors.

→ The acceleration in dynamics in some areas caused by the Covid-19 pandemic, apart from making the digitization process even more pervasive, impinged on value spheres not directly correlated to the pandemic. Alongside a revived sense of urgency towards global challenges, above all those relating to the **environment and to climate change**, there is a reawaken interest in **the role of education and research**, where universities are seen as a key factor for interpreting and steering change, and are called upon to renew their role and their duties.

TOMORROW'S PROFESSIONS

At the micro-level of companies and organizations, the pandemic crisis has caused several processes already underway to gather speed, especially the impact of digitization on the very nature of work and the skills now required. This situation brought home the categorical impossibility for contemporary social and economic systems to base their professional development on generational changeover. Many studies indicate that, over the next ten years, nearly two-thirds of workers will have to change type of work and all will be forced to evolve to meet the changes brought about by new technologies. According to these studies, it will still be difficult to replace **creativity, planning ability and other skills** typical of the creative professions and of research, or to make it without a high level of **"social intelligence"** and the **capacity to manage complexity, risk and the unexpected**, which are all particularly beneficial in healthcare, education and services in general.

As well as these skills, one idea taking hold is that education should concentrate on **developing people's cognitive powers**, in other words, cultivating an aptitude to learn rather than focusing on purely transferring material that could easily soon be obsolete. Even the changes affecting the organization of companies and professions are open to a review on the training side, where more agile structures are typically associated to higher degrees of delegation and more autonomous professional figures whose duties cover a wider range of functions carried out within teams working collaboratively. Career paths are also changing and people are unlikely to spend their entire working life within a single organization and will instead be inserted in elaborate multi-structured networks. For this reason, work itself, even within a company setting, is taking on the features of an autonomous profession, functions are less rigidly defined and there is the continuous need for people to upgrade their skills and reconfigure their roles.

In this new millennium, human resources and knowledge are unequivocally taking on a central role as factors driving development; equally, the response models put into play so far by universities may not be up to the job today.

A COMPARISON BETWEEN CONTEXTS OF REFERENCE

The political and economic dynamics unfolding across the world produce very diverse systems that act as catalysts in concentrating human and economic capital, thus influencing strategic choices in universities. The models introduced to exploit technical and scientific knowledge vary significantly country by country. Taking one model as example, where:

① **INPUT:** public and private resources invested in research;

② **OUTPUT:** the findings issuing from research (patents and publications) and the population's profile for percentage of adults with degrees and percentage of people employed in technical and scientific fields[1,2];

we can identify two main systems underpinning technical and scientific knowledge.

The **"push"** model, as applied for instance in Germany, Sweden and the Netherlands, is where the **private and public sectors invest seriously in research**, and the "pull" model, as applied for instance in the USA and UK, is **where great pressure is placed on productivity, stimulated by mainly private investment**.

These two reference models are joined by the **many situations in evolution or contraction**, which can differ substantially one from another. In Italy's model, for example, productivity is good compared to the resources invested, which however have been decreasing for dozens of years and are certainly below the OECD average (black line in the diagram below) in all reference measures.

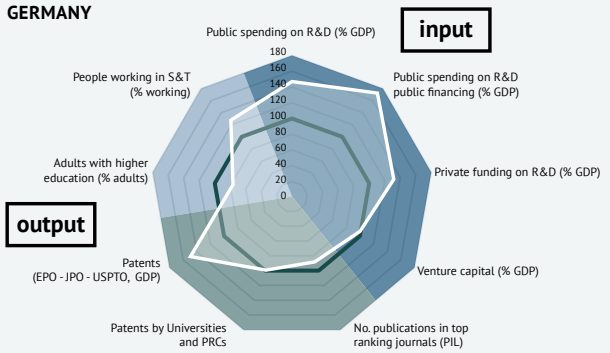
In models that have been studied at length, such as the American Super Research University (SRU) model, it is clear that new knowledge and the expectation of it being transformed into innovation is closely connected to the university interacting with external non-academic actors, and so is often inherently multi-disciplinary and heterogeneous. In this landscape, universities are increasingly expected to be more involved in the outside world, to encourage the economies of innovation and promote collaborations with private businesses to engender new entrepreneurship (start-ups and spin-offs). The ensuing innovation mirrors the strategic choices that universities are planning, guided by their interaction with the local ecosystem and the international networks to which they belong.

Given the known impact that universities have on the dynamics of local development, one outcome is to expand their mission, progressively driving them to become true incubators of the entrepreneurial world and to engage more closely with civil society.

1 Adapted from: Gherardini, Squarci nell'avorio, Firenze University Press, 2015

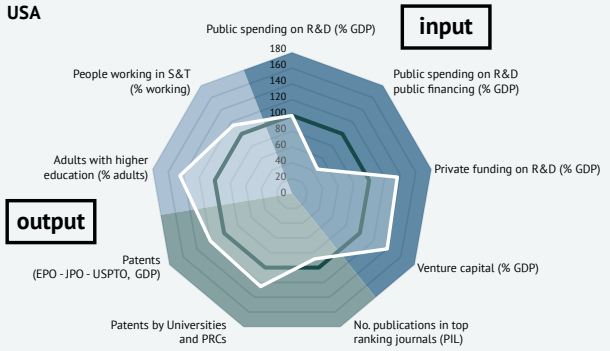
2 OECD data.

HIGH INVESTMENT



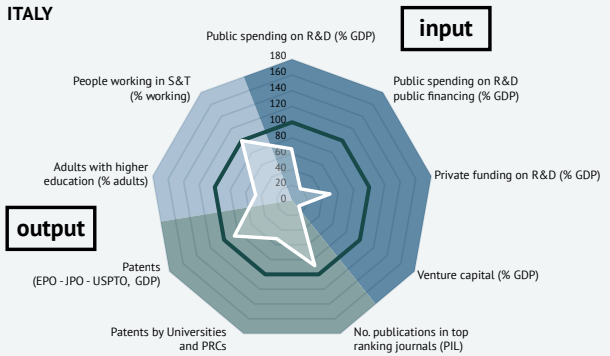
E.g.: Switzerland, Germany, Sweden, Netherlands, South Korea

HIGH PRODUCTIVITY



E.g.: USA, UK, France, Japan

GROWTH OR CONTRACTION



E.g.: Italy, China Russia, Spain

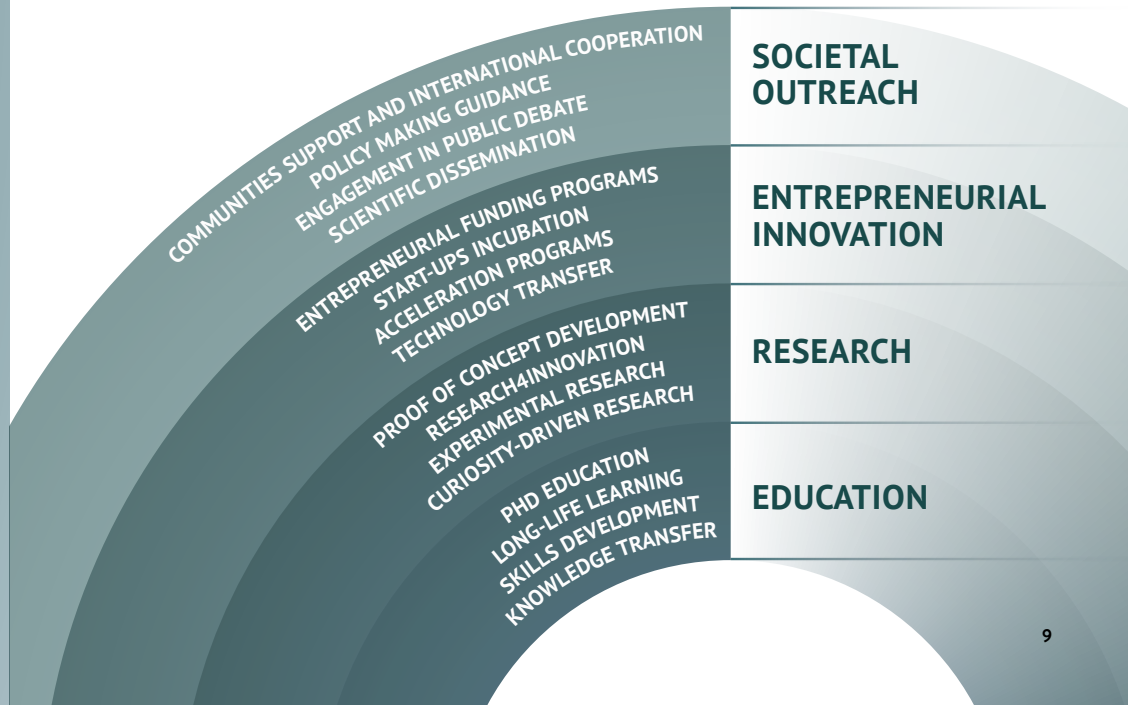
100 - OECD average | resources in input | research results | population profile

2

EVOLUTION IN UNIVERSITY SYSTEMS

Technical and scientific universities today hold a role in society which has radically changed from the past.

Alongside **education** and **research**, those time-honoured propellors of development, other facets are making headway as part of the universities' objective to maximise their impact on society. The frontrunners are transfer of technology and knowledge towards the productive system to support **entrepreneurial innovation** and interaction with the community through **social outreach** programmes. Entrepreneur-led innovation means using technological innovation to create new tangible applications, which can ultimately lead to new companies and new jobs, which can contribute towards tackling the great global challenges. Outreach programmes refer to the primary role the universities must take in spreading knowledge, in bringing scientific culture to the wider community, and in defining public and private development policies. This four-way subdivision of a university's mission gives a clearer picture of the models adopted and the trajectories being followed.



EDUCATION, RESEARCH, ENTREPRENEURIAL INNOVATION, AND SOCIETAL OUTREACH

Universities are accordingly expected to address challenges spanning across the many layers of relationships and impact on society. In education, there is a general tendency to design educational projects **around an individual**, planning **personalized study programmes** that start during the students' traditional university period and then extend throughout their professional life (**life-long learning**). In the new storylines for designing education and training programmes, there is an interweaving of in-**presence and distance learning** underpinned by new digital technology, which took such great strides during the pandemic. People now required to meet challenges of ever-deepening complexity must be backed by studies that train them to work in **multi-disciplinary teams**, to hone their adroitness in amalgamating knowledge, skills, and languages, and to know how to combine theoretical approaches and empirical models when setting and solving problems.

Turning to research, there are various trajectories of evolution. There is, in general, a tendency **to broaden the spheres of interest**, with technical and scientific universities, for instance, developing projects whose scope covers **basic and life sciences**. Across all universities, there is a swelling interest in inducing convergence between research interests and **global challenges** and a general pressure on increasing **scientific productivity**. These dynamics are often driven by the financing policies behind competitive tenders and the system of allocating public resources, more often than not now focused on assessing scientific results on the basis of bibliometric measures. The place of **research doctorates** is under greater scrutiny, especially as a beneficial link between academia and ecosystem of reference for plans and programmes that encourage innovation.

Starting from several virtuous models linking up universities and innovation ecosystems (MIT in the Boston neighborhood and Stanford and Berkeley in the Silicon Valley), it is becoming increasingly clear that universities can potentially act as **power units for developing the social, economic and production systems**. There is a general tendency to promote strategies that prioritize innovation and entrepreneurship within study programmes, and see them as key features of success for young researchers.

Lastly, the value of knowledge and information in society calls for universities to take on new forms of more **active presence**, asking them to contribute more directly to public debate on the great topics, and join the public-private discussion to define their **country's development policies**. The pressure pushing universities towards taking a leading role in society is backed by policies in support of sustainability, diversity, and inclusion, and these policies, in turn, can give universities an entrance into projects with a high social value and a place at the table in programmes of international cooperation.

POLITECNICO DI MILANO'S POSITIONING

Politecnico di Milano is today expected to take on different roles in the various settings in which it operates, adopting strategies that are calibrated to whom it is dealing with, whether the local ecosystem, the national panorama or the networks of international connections in Europe and across the world.

Some features of the Italian university system are peculiar to Italy. These include **a low rate of tertiary education** (18% out of the total working age population, against 37%, the OECD average) and a high level of **under-funding** compared to other countries and the OECD average (Italy invests 1.5% of GDP in research and development, against the OECD average of 2.5%). These two issues act as a mirror to reflect a university system sheared into sixty or so public universities (and about thirty private ones) where the average **quality is indisputably good but there are no peaks of excellence** (and no troughs either). This situation is certainly unlike that of other countries (the United States or China, for instance). The logics In Italy of distributing resources evenly but inevitably thinly across the university system is having a strong impact on the direction of research at Politecnico di Milano, directing it towards **international funding**, mainly within Europe, and to expanding the scope of research projects, often engaging with **actors in the industrial world**.

For Politecnico di Milano, the Italian national university system is the reference context with most constraints, as it is fully regulated by the Ministry for Universities and Research. On the teaching front, while restraints imposed centrally tend to hinder the dynamics of change, Politecnico has launched several innovative initiatives, among which **Master's degrees in exciting new transdisciplinary subjects**, often brought into being through strategic alliances with partner universities. Alongside these initiatives, the university's focus on consolidating its dominance within the landscape of university education runs hand in hand with the high quality of graduating students, whose value is recognised in the economic and production system, locally, domestically and internationally.

In the field of entrepreneurial innovation, Politecnico di Milano interacts locally with a regional ecosystem that differs substantially from that of Italy's economic system as a whole. Lombardy is one of Europe's wealthiest regions (and was placed fourth in Europe for GDP in 2018 -Eurostat, 2020). That said, the landscape consists primarily of small and medium-sized businesses, often family-run, whose models of structural innovation are not yet consolidated. At the same time, the university also works closely with public authorities where low investment in internal skills is matched by chronic underfunding which blocks them from drawing on skills from outside their walls. In order to respond flexibly to this situation and become the standard-bearer for policies of innovation, Politecnico was one of the first Italian universities to set up a **university incubator** and among the few in Europe (and the only one at home) to support its development through the creation of investment funds.

On the front of **involvement in society** through outreach programmes, now fully recognised as a university's fourth mission, Politecnico has recently expanded on its initiatives geared towards promoting **inclusivity and the appreciation of diversity both internally and externally, and cooperating in projects with a social impact**. Connected to this thread is a renewed drive to work on the sphere of human and social sciences within the setting of education, as well as in that of research and research impact assessment. Many technical and scientific universities are taking this path, and the route will inevitably have to be firmed up further in the future.

INTERNATIONAL COMPARISONS

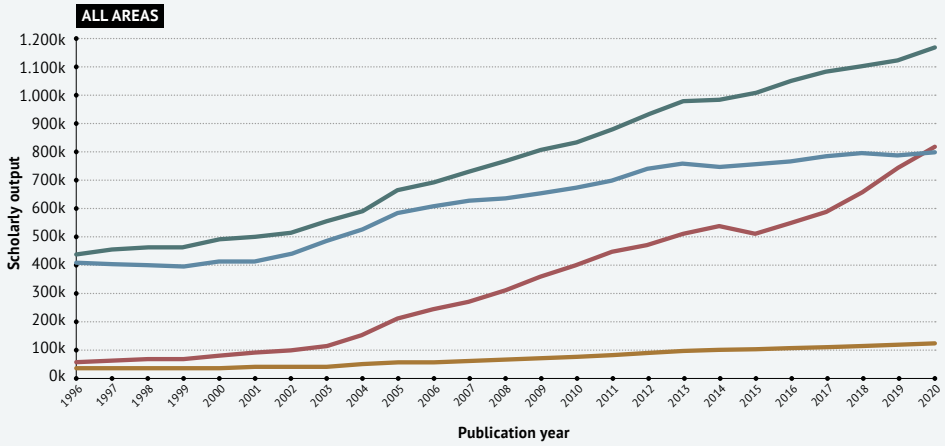
Politecnico di Milano is drawing up its development strategy within an international competitive system, where those set by similar leading universities determine their ability to attract students, academic teaching staff, financial resources and the development of collaborative relationships on an international scale.

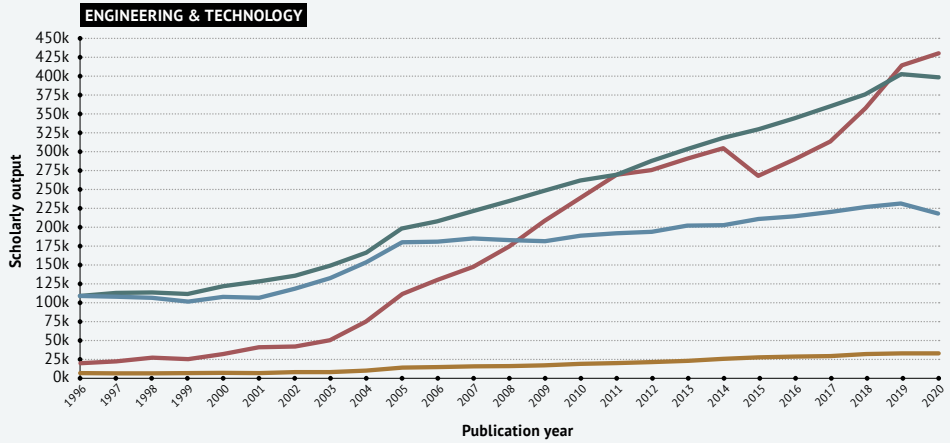
In terms of research, very diverse dynamics colour the bibliometric analysis of scientific productivity in different geographical zones (Europe, North America, Asia and Australia) for a set of subjects (engineering, natural sciences, life sciences and medicine).

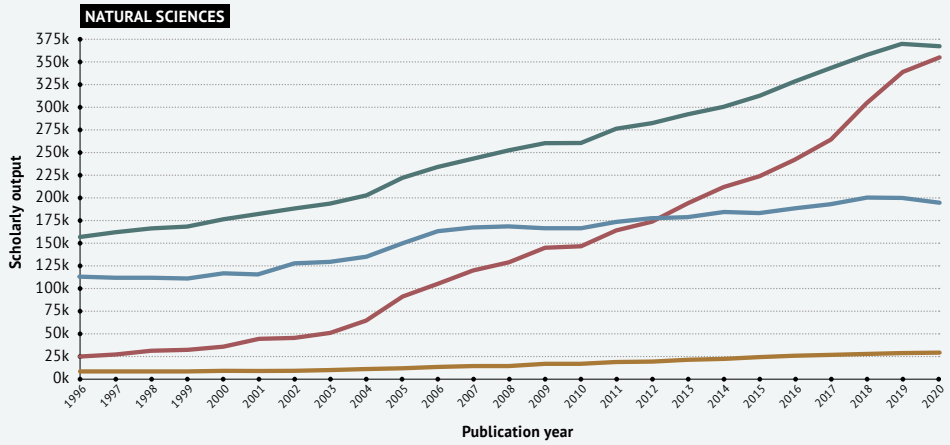
Asian research systems show a significant and continuous upwards trend in bibliometric productivity, concentrated above all in engineering and natural sciences.

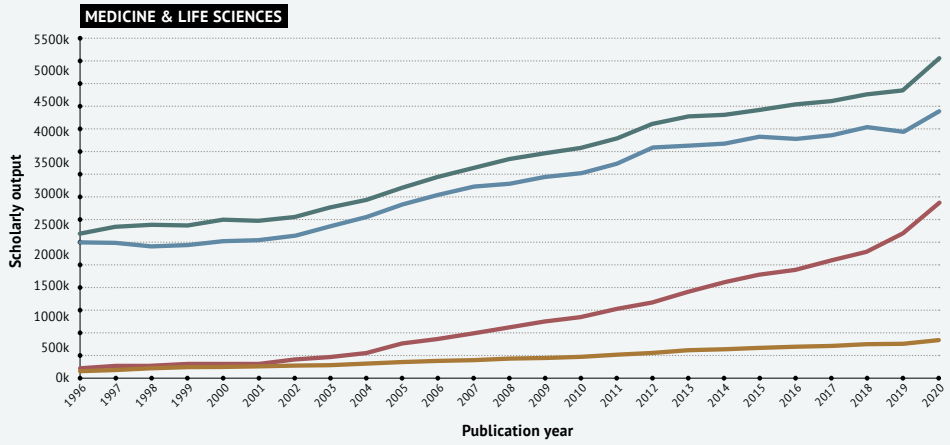
Scientific Productivity (number of products) in all areas, in Engineering and Technology, Natural Sciences, Medicine and Life Sciences in Europe, North America, Far East and Australia (source: Scopus – SciVal, QS classification areas)

EUROPE | NORTH AMERICA | FAR EAST | AUSTRALIA









The different geopolitical strategies for funding research and being competitive on the quantitative results of such research translate inevitably into major differences between the universities that are in competition with each other on the international stage.

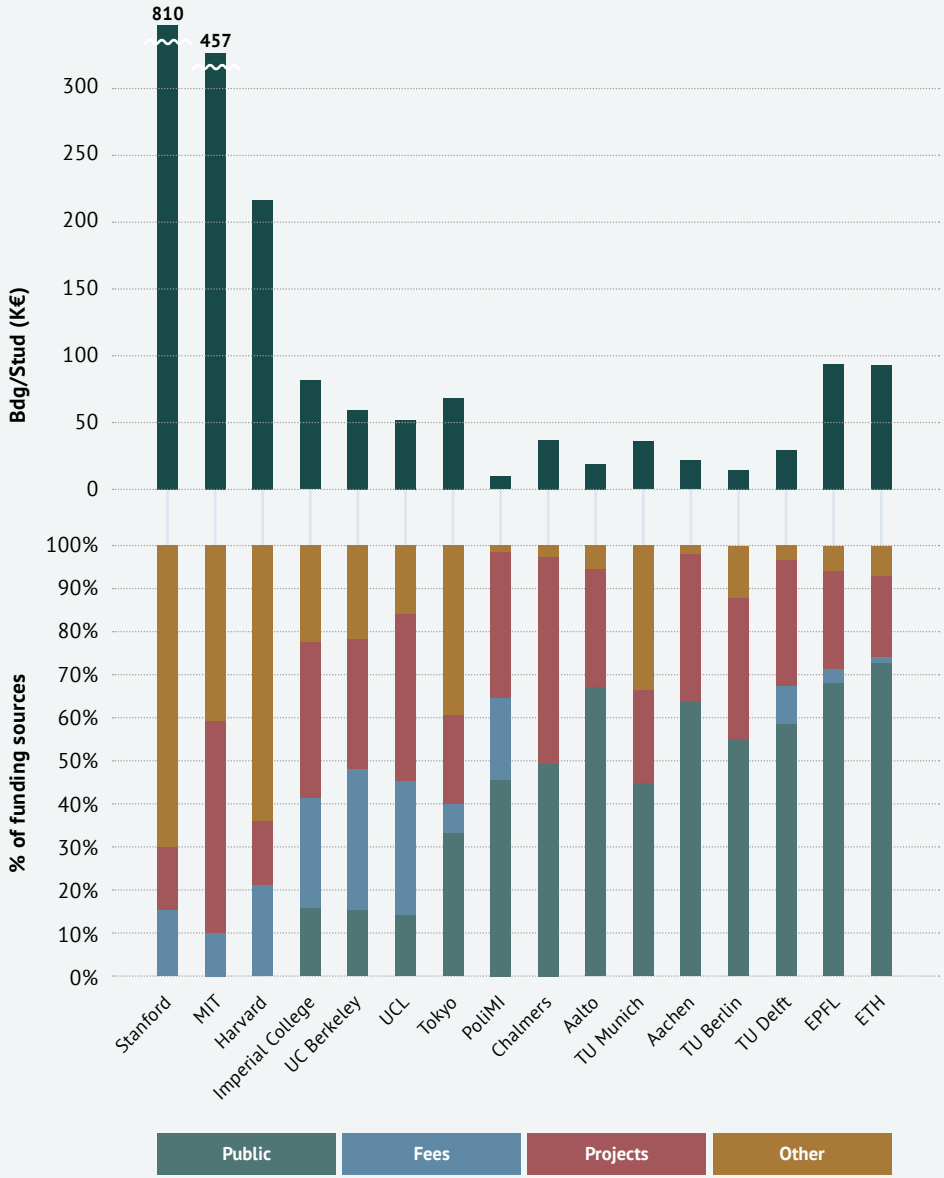
If we look at the budgets of a small group of representative universities normalised to the number of students, we can easily extrapolate several reference models:

→ **American private universities** (i.e. private universities like Stanford, MIT, Harvard), which can field a budget per student that is decisively above those of all other universities and whose financing arrangements derive mainly from operations that are not connected directly to education and research (financial and real estate business).

→ **Swiss public universities** (ETH, EPFL) where the budget pro student is close to € 100K, and basically comes out of the public purse.

→ **Public universities in the USA and UK** (Imperial College, UCL, Berkeley), whose pro student budgets are made up in great part by student fees and research projects.

→ **European public universities** (RWTH Aachen, TU Munich, TU Berlin, TU Delft, Chalmers, Aalto, PoliMI) with pro-student budgets of less than €50K, largely from public funds and research projects.



Spending per student and percentage of funding sources in several universities of reference (source: financial statements published by universities for 2017).

Staffing structure and student/staff ratio also bring up a wide array of models.

First, by analysing the **ratio between teaching and research support staff** (PhD students, post-docs and postdoctoral researchers) and **academic staff** (faculty), we can identify three reference models:

→ Ratio of 10 to 20: the model used in the leading Swiss universities and Germany's great technical establishments, with a few figures at the apex who coordinate the work of a great number of PhD students, post-docs and postdoctoral researchers.

→ Ratio of 3 to 5: the most common model, widely used throughout central Europe (TU Delft Chalmers, KU Leuven) and by other leading international universities (MIT, NTU Singapore, Stanford).

→ Ratio of 1 to 2: the model used among others by PoliMI and CentraleSupélec, where the number of young researchers (PhD students, post-docs and postdoctoral researchers) is still not high.

Similarly, the difference between models clearly emerges if we consider the **number of undergraduate and graduate students per staff member** (both tenured faculty and "young faculty"):

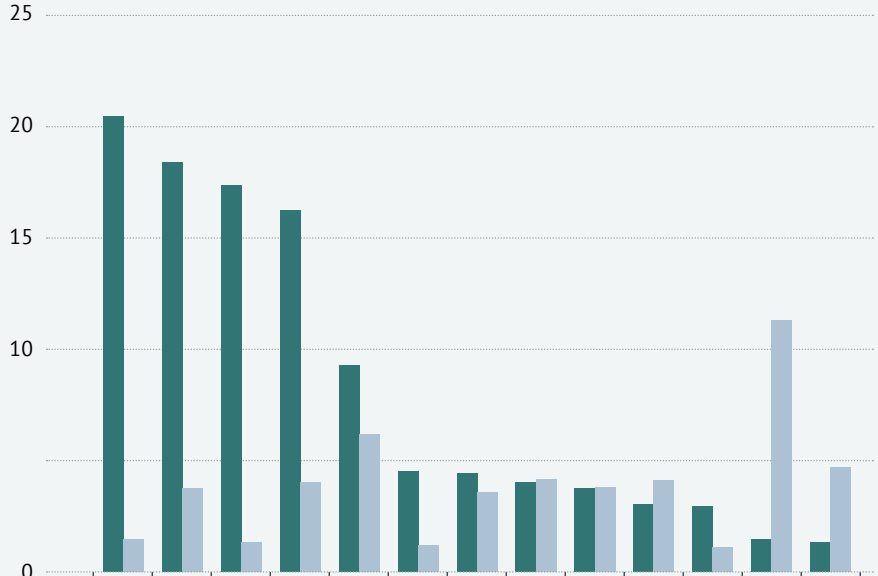
→ 1 to 2 students per faculty member: the model used in leading Swiss and American universities (ETH, EPFL, Stanford, MIT).

→ 3 to 6 students per faculty member: the model used in all the other universities (RWTH Aachen, TU Munich, NTU Singapore, TU Berlin, Delft, Chalmers, Leuven, CentraleSupélec).

→ More than 6: PoliMI alone stands apart from all other universities, with more than 11 students per faculty member. The reason for this is the combination of a high number of students and a low number of tenured teaching faculty and teaching and research support staff (PhD students, post-docs and postdoctoral researchers).

Another interesting comparison can be made on the map of the **emerging themes** being researched in leading technical universities ("topic prominence" in Scopus SciVal). From this analysis it emerges that there is a general tendency to extend the scope of interest of technical universities from topics more strictly related to engineering (blue areas) and basic sciences (purple areas) to topics connected to life science and medicine (red areas); this trend is probably encouraged by the global challenges that direct funding policies.

Students and Faculty



	ETH	Aachen	EPFL	TUM	TU Berlin	MIT	NTU	TU Delft	Chalmers	KU Leuven	Stanford	PoliMI	Centrale Supélec
Young Faculty per Faculty	20,5	18,4	17,4	16,2	9,3	4,6	4,5	4,1	3,8	3,1	3,0	1,5	1,4
Students per Faculty	1,5	3,8	1,4	4,1	6,2	1,3	3,6	4,2	3,9	4,2	1,2	11,3	4,9

Ratio between teaching and research support staff (PhD students, post-docs and postdoctoral researchers "young faculty") and academic teaching staff ("faculty").

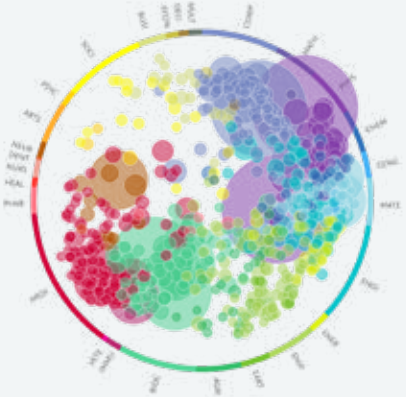
Ratio between undergraduate + graduate students and total number of teaching staff (including PhD students, post-docs and postdoctoral researchers).

POLIMI

CHALMERS

TU DELFT

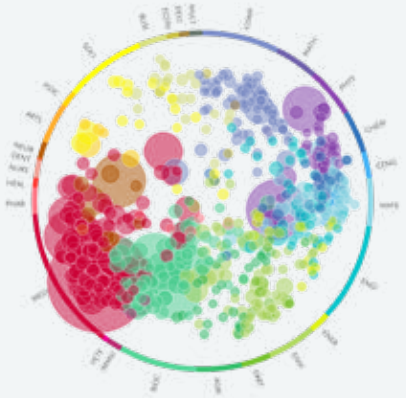
MIT



AACHEN

TSINGHUA

HARVARD



STANFORD

SJTU

COMP	Computer Science
MATH	Mathematics
PHYS	Physics and Astronomy
CHEM	Chemistry
CENG	Chemical Engineering
MATE	Materials Science
ENGI	Engineering
ENER	Energy
ENVI	Environmental Science
EART	Earth and Planetary Sciences
AGRI	Agricultural and Biological Sciences
BIOC	Biochemistry, Genetics and Molecular Biology
IMMU	Immunology and Microbiology
VETE	Veterinary
MEDI	Medicine
PHAR	Pharmacology, Toxicology a nd Pharmaceutics
HEAL	Health Professions
NURS	Nursing
DENT	Dentistry
NEUR	Neuroscience
ARTS	Arts and Humanities
PSYC	Psychology
SOCI	Social Sciences
BUSI	Business, Management and Accounting
ECON	Economics, Econometrics and Finance
DECI	Decision Sciences
MULT	Multidisciplinary

Prominence map for several universities (source: Scopus, SciVal 2016-2021).

3

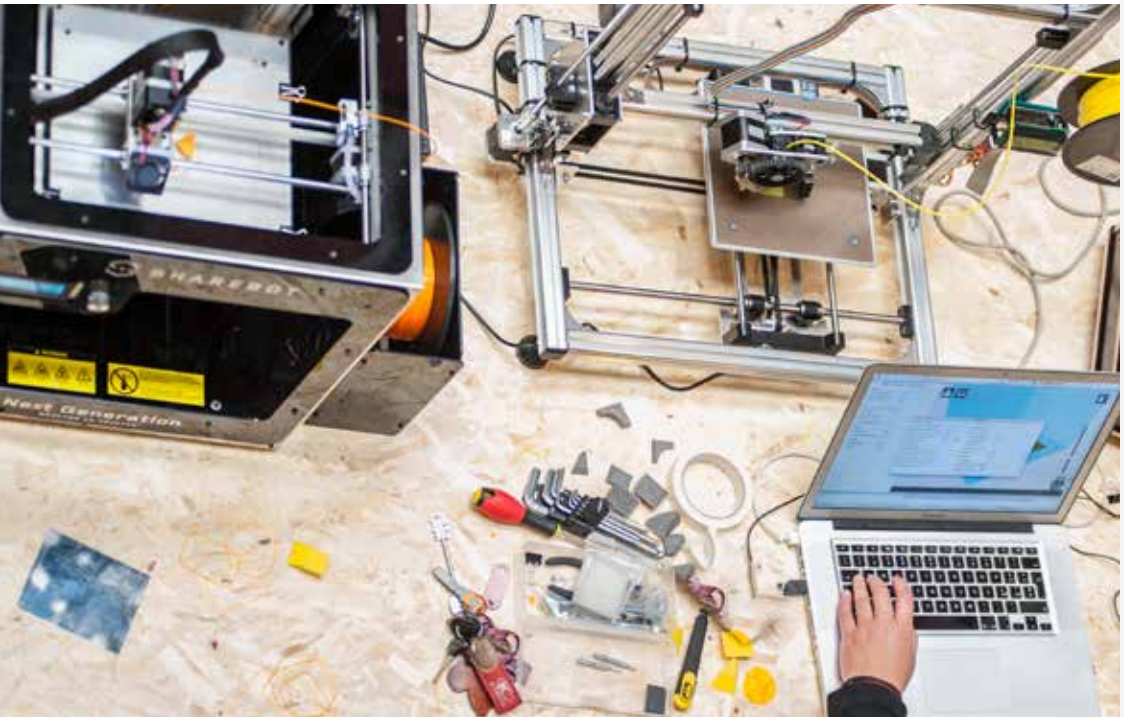
POTENTIAL STRATEGIC DIRECTIONS

As we have argued, universities are potentially poised to take on a new and different role in society. Their duties will not be restricted to education and research, but will increasingly involve spreading innovation as an opportunity for development, contributing to designing policies and supporting their local community and territory. This new function will draw universities out of their customary traditional boundaries, demanding that they should respond by deploying an innovative capacity to manage complexity, in a new intricate and multi-layered world that is becoming ever more difficult to interpret.

We reached this point in our trail of investigations and interpretations having started from the analysis of the four elements that compose universities, which we examined and defined, expanding on relatively consolidated models, namely: education, research, entrepreneurial innovation, societal outreach. However, looking at the challenges thrown up by the social and economic landscape, as well as by scientific and technological progress, the university world is facing choices that must be taken from within a new framework of reference.

Looking to the future, the elements which can direct the choices that a university will have to make are associated to what it will do and **how it will be able to generate new enriching knowledge**, with whom and for whom, meaning **which relationships it should establish**, and lastly, how it will be able to **govern and manage all the necessary decisions** and operations to balance flexibility and efficiency.

We, therefore, are proposing to reformulate the strategic challenges that universities will come up against in the future along three axes: **knowledge, relationships and system**. We can move around in our new framework and, when planning a path of evolution, ask key questions that are closely linked to the context in which each university is embedded. The three axes outline a strategic orientation space and are set out according to two-way polarities that represent the possible directions on which to base future decisions.



KNOWLEDGE
how to create it,
transfer, communicate,
manage and hybridize

RELATIONSHIPS
how to establish
and manage them towards
inside and outside,
what role to give to each
group and individual

SYSTEM
How to govern
the complex system,
how to identify goals
and guide processes

KNOWLEDGE

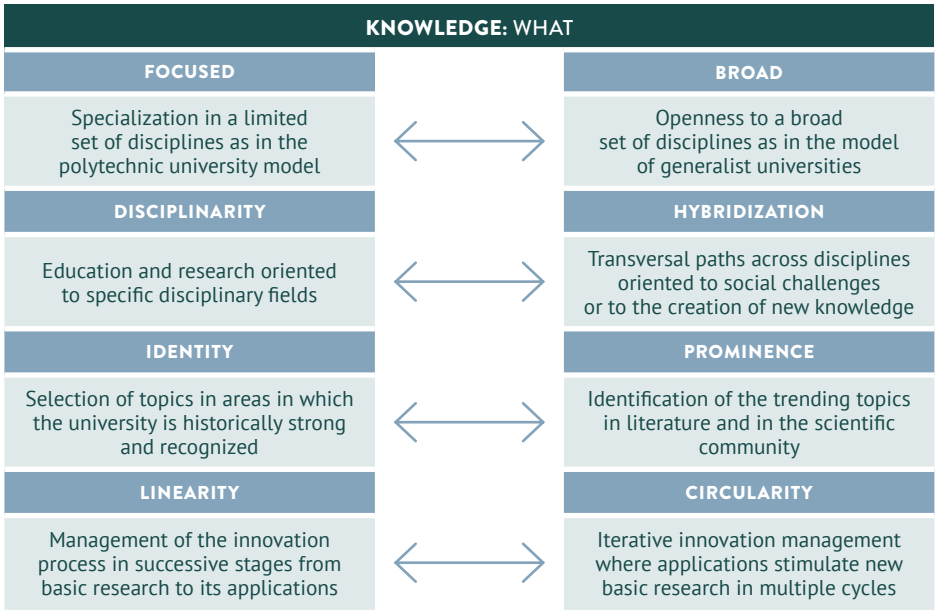
How to create it, transfer, communicate, manage and hybridize

The first axis expresses the strategies and modalities to generate, transfer, communicate and share knowledge, in a difficult balancing act between subject-specific and vertical approaches, and other more horizontal approaches that can sweep across the boundaries separating disciplines and the seeking of solutions, starting from the great problems of this age. In today's world of rapidly evolving technology, if a university is to contribute to the progress of knowledge, it must be, by implication, at the **furthest outposts of these subjects** and have sophisticated skills and research tools, as well as strong ties with actors in the economic system that can translate every advance achieved into practical solutions. Universities are not always in a position or have the resources to make such contributions across a wide set of fields, and have to take strategic decisions on the basis of specific moments in time. By contrast, progress is increasingly more often the outcome of practical needs, where issues are addressed through a combination of radically new skills and creating the conditions for these new fields of knowledge to spring forth. Despite the popularity of multi-disciplinary approaches, fertile collaboration between subject matters is not easy to attain, and rather comes from the power of applying knowledge, a comprehensive understanding of the problems that need dealing with and an alertness towards human and social aspects.

A science-tech university is better placed to interpret future challenges in knowledge, using **positive cross-fertilisation** as the distinguishing emblem of its actions. For this reason, such a university needs to concentrate on areas where projects are key to achieving clearly-identified objectives and where all significant elements are taken into account. Excellence in some subjects can lead to an escalation in opportunities for making a real difference if inserted in contexts where it makes strategic sense to collaborate with other spheres and concerns the toughest application challenges of the modern world.

Research can continue to be engrained in the distinctive traditional topics of the various cultural areas, but it must also have the strength to define questions that will then attract great interest from international research. Creativity in imagining new approaches with a wide-angle view of social needs must be the tool to direct the attention of research communities to **new relevant topics**, without merely going down well-trodden paths or chasing fleeting matters.

Collaborations with the productive world and start-ups can transform into cross-fertilisations for innovation if research results are not just transferred down a one-way flow, but by creating cycles that circulate back from real applications and stimulate new research and more solutions with a practical impact.



RELATIONSHIPS

How to establish and manage them towards inside and outside, what role to give to each group and individual

The second axis, relationships, directs attention towards the importance of the various relationship systems that every university slots into (as well as each single researcher and teacher), to identify the potential advantages and disadvantages of strategies based on competition and empowering individual universities (researchers and teachers) or strategies based on empowering networks to improve and enrich teaching and research.
The future of technical universities will be decided by their relative degree of openness or closure in teaching, research, capacity to innovate, and in how they connect with the educational systems in individual countries and in Europe more broadly, especially in terms of their relationships both with their peers and with other actors.
The two potential models of reference are, on the one side, a **self-contained** and **self-sufficient** university that excels in research and features high-profile **researchers who are unique in their field**, and which produces all its teaching material on its own and aspires to educate a **national or global elite**. On the other side is the more open, **network-connected** university that comes up with good research because of its infrastructuring layers and **extended research groups**. This second university networks with other universities in its teaching offer, it belongs to **solid nation- or continent-wide university systems** of good quality across the board, that address a **potentially broad audience** of young people aspiring to receive a technical education.

Naturally, no university fits perfectly into one of the two models; while sharing and projecting towards the outside has been the blueprint of universities since the Middle Ages, it is certainly true that they also feature a strong internal organisation. The intensity and density of their relationships and connections is a major trait, as is a faculty that identifies with its university, especially when in greater competition for dwindling resources. At the same time, we believe that this polarisation is effective, as it gives an intuitive and immediate representation of the two models, between which universities are swaying and have always swayed.

The polarity between self-sufficiency and collaboration in a network approach can be addressed both from the teaching side, where it intersects teacher and student mobility, and from the research side, where it intersects with sources of investment and infrastructure.

One specific point, that of the models for interacting with students, looks at the different forms of teaching spanning **physical interaction and digital tools**, which can be played out along several dimensions, starting from classes that are totally in presence and live, to a range of alternatives that deploy asynchronous and mixed models and are based on active learning, alongside more passive traditional methods.

RELATIONSHIPS: WHO

SELF-STANDING	⟷	**SHARING**
Self-sufficient university and self-contained in the education offer		University connected in a network with others exploiting synergies and complementarities in teaching
COMPETITION	⟷	**COLLABORATION**
The university aims at a recognized individual excellence in research		The university collaborates within consolidated research networks at the international level
STAR	⟷	**TEAM**
Recruitment of excellent researchers of established high reputation		Articulated and horizontal research groups, consolidated over time
DIGITAL	⟷	**PHYSICAL**
Education based on digital technologies, passive learning, asynchronous mode		Education based on physical interaction, active learning, synchronous mode
UNIFORMITY	⟷	**CUSTOMIZATION**
Education models and paths common to all students		Learning paths built on students' characteristics and interests
RIGHTS	⟷	**MERIT**
University aiming at inclusion and the increase of skills and competences on a large scale		Selective model rewarding individual and group capabilities and potentials

SYSTEM

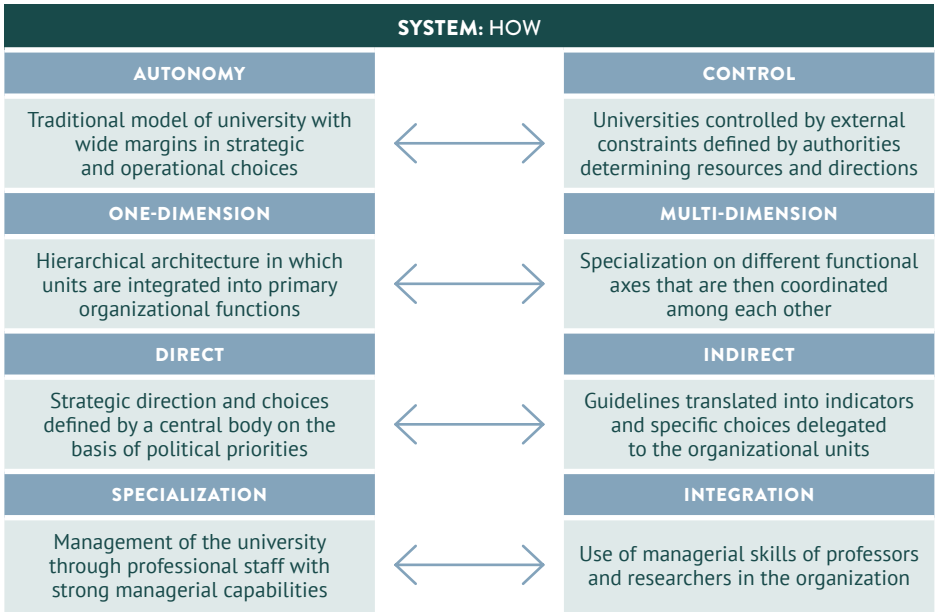
How to govern the complex system, how to identify goals and guide processes

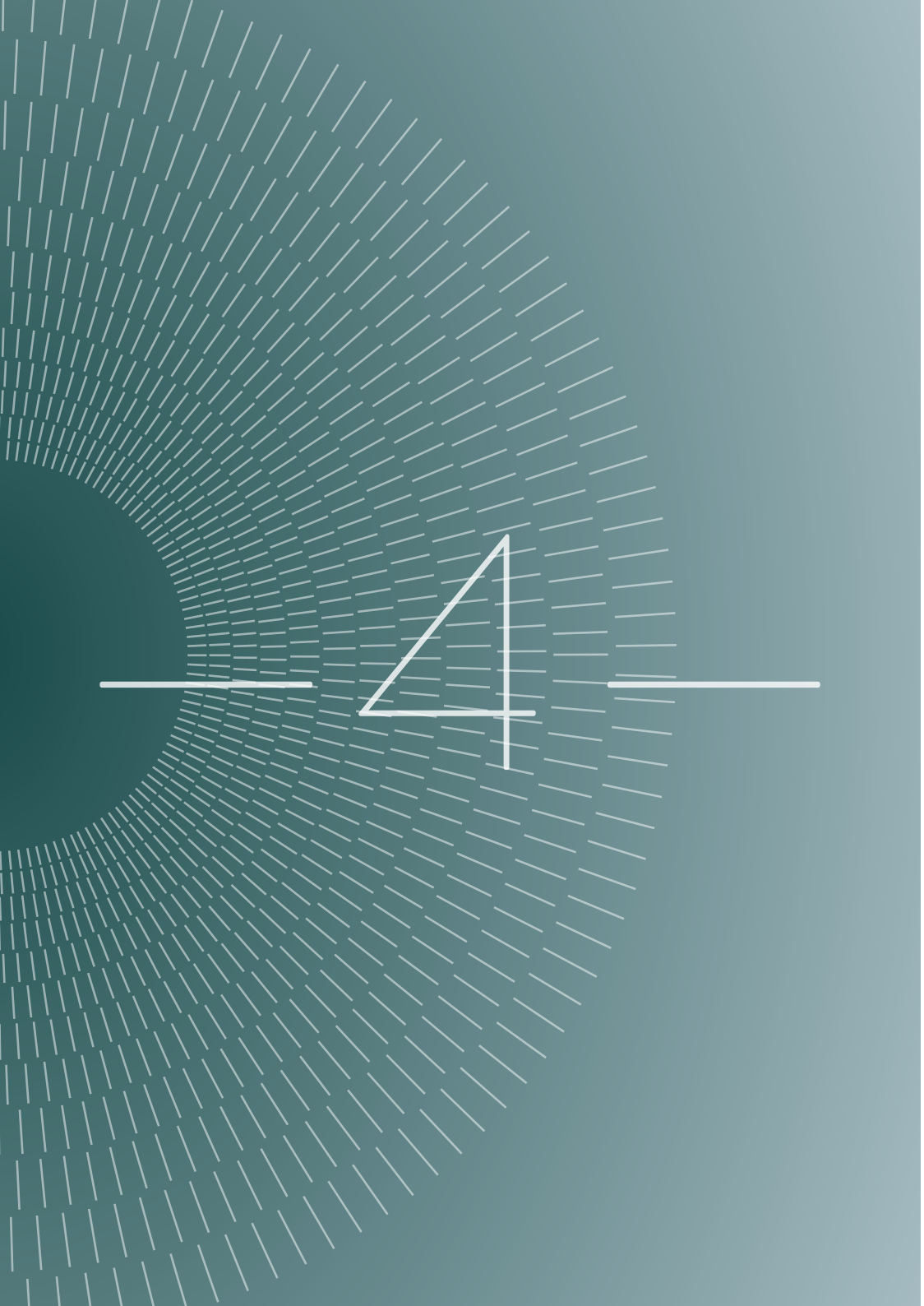
The dimension of knowledge and that of relationships are both enabled by the third axis, system, which is concerned with "how" a university is run, in other words, the governance models in the single universities and in the overall university system whereby the choices along the first two axes are both possible and feasible.

Here, to build a system in **balance between desired flexibility and necessary constraints**, a technical and scientific university can try to conquer margins of autonomy, loosening the leash of public overseeing authorities by displaying well-balanced management capacities and exploiting a range of funding sources, in order to interact virtuously with the external system without being under its direct control.

Where possible, the ideal route is to build a many-layered multi-dimensional **governance system**, placing within different units the responsibility for education, research and responding to application challenges and from society, avoiding overly vertical and single dimension arrangements. The needs emerging from the various quarters can be formulated by defining strategic objectives and making choices, at least for the most critical questions, through a central body that sets **clear policy guidelines**. The peripheric facilities can deal with the more mundane questions, where control is exerted through indicators connected to the strategic objectives.

To understand and address external challenges effectively, universities must know how to select the cutting-edge topics and matters where they will invest energy and resources, dipping into internal and external professional expertise. Lastly, in the always delicate balancing act between managing internal processes in the various organisational units and elaborating content (for education, research, innovation and outreach), universities must know how to build contact and exchange points between the people in its organisation, ensuring a **better use of individual skills and specialisations**.





TOWARDS THE THIRD ACADEMIC REVOLUTION

After the First and Second Industrial Revolutions, universities went through a First Academic Revolution, expanding their scope from education to research. After the Third Industrial Revolution, they faced a Second Academic Revolution, this time expanding their mission to innovation and technological transfer. Recent developments in what we refer to as the Fourth Industrial Revolution, and probable technological developments in other domains, will today encourage scientific and technological universities, especially, to become critical actors and society's bastions in developing research, technology, skills and, above all, helping to frame long-term public and private policies.

This setting could lay the groundwork for the **Third Academic Revolution** and could find even more fertile ground where governments will develop clear industrial development policies at the national and international level, based on technology evolution and recognition of competencies and skills.

Even more, in a more and more complex society, the balance between democratic debate and competence recognition will assume a crucial relevance. The conciliation between the **majority principle and the competence principle** has never been easy, and in the future years universities will play a decisive role in this challenge. From here it is possible to imagine evolution trajectories including structured activities in managing knowledge to **support political decision making both in the public and in the private sector**, together with clear forms of **participation in the debate** towards citizenship.

Each university shall interpret its own strategy along the dimensions of knowledge, relationships and system, based on its own features and the eco-systems they live in. Those ecosystems will be more and more characterised by **augmented cognitive capabilities** and by a **general increase in the cultural level of population**, with a continuous and progressive extension to tertiary education.

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